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METHODS

OF

PRACTICAL HYGIENE.

METHODS

OF

PRACTICAL HYGIENE

BY

PROFESSOR K. B. LEHMANN
WÜRZBURG

TRANSLATED BY

W. CROOKES, F.R.S.

WITH NUMEROUS ILLUSTRATIONS

IN TWO VOLUMES

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SECTION VI.

MEAT.[1]

§ 236. A right supervision of the nutrition of mankind with meat in the most extended sense of the term is practicable only if there is performed a twofold investigation. On the one hand, the health of the living beast must be pronounced on by the veterinary surgeon; and on the other, after slaughter, the flesh, and especially the intestines, of the animal must be examined by an expert. In consequence of the eminent importance of a correct decision upon meat, the necessary knowledge should become also the common property of medical men.

An inspection of the flesh of game and poultry has been hitherto almost universally deficient. At most its freshness is tested.

A. Examination of Meat.

§ 237. In the examination of meat it is not sufficient to say whether a sample in question is injurious to health or not, as in many cases meat, without being strictly hurtful, may evince properties or changes which make it disgusting,[2] and hence unfit for public consumption. Though we must, as far as possible, distinguish between what is loathsome and what is unwholesome, an absolute line cannot be drawn, as in sensitive persons the consumption of a disgusting substance may be directly injurious to health.

For a correct decision we must take up the following questions:—

[1] By "meat" we understand in these pages the entire recent animal nutriment, therefore including the edible viscera.

[2] A rigid, universally valid definition of "disgusting" cannot be given. Disgust is excited among individuals with very different readiness, and a substance is often consumed in ignorance with the best appetite, though it would have been rejected with loathing if particulars about it had been known.

a. Is the meat fresh, or advanced in decomposition?

b. If the meat is fresh:

1. Is it derived from a healthy animal?
   - *a.* Was the animal in conditions of life and nutrition such as to cause its meat to appear faultless?
   - *β.* Is the flesh of the beast, in consequence of peculiar circumstances (*e.g.*, the manner of slaughter), more or less disgusting, or at least of inferior value?
2. Was it obtained from a diseased animal?
   - *a.* Was the disease infectious, and, if so, what disease?
     - a_1. Was the animal greatly wasted or reduced by disease, and can perhaps other morbid symptoms be detected in the meat?
     - β_1. Has the animal taken medicines which may be of importance?
   - *β.* Was the disease infectious but not communicable to man, and if so what disease?
   - *γ.* Was it a disease capable of being communicated to man, and if so what disease?
     - a_1. Is the danger removed by cooking?
     - β_1. Does the danger remain after cooking?

I. *THE EXAMINATION OF MEAT FOR ITS PROPORTION OF NUTRIENT MATTER.*

§ 238. The chemical examination of meat for its chief components (water, albumenoids, fat, ash) is scarcely performed for hygienic purposes, as sufficient analyses are available, and as frauds and dangers to health cannot thus be detected. If necessary, it is performed according to the general methods laid down in § 209.

The composition of muscular tissue fluctuates greatly, according to its proportion of fat. (See Table IX.) Fat meat is always absolutely poor in water; the proportion of albumenoids in fat meat is generally somewhat, and sometimes considerably, smaller than in lean meat.

The difference between meat as tough or tender, dry or juicy, savoury or insipid, cannot as yet be sufficiently explained chemically.

It is estimated that an ox contains from 40 to 48 per cent. of muscular flesh, 11 per cent. of bones, and 11 to 25 per cent. of fat. According to Friedel, meat, as bought of the butcher, contains as an average 83 per cent. of muscular flesh, 8·4 per cent. of bones, 8·6 per cent. of fat.

As among us there is no kind of animal known the flesh of which is *per se* injurious, the detection of the substitution of one kind of meat for another is of hygienic importance only in as far as the flesh of horses, dogs, and cats in our districts seems more or less disgusting to most persons. Berlin consumes yearly 8000 horses.

The distinction between the various kinds of meat is easy for the veterinary surgeon trained in comparative anatomy, in so far as the bones, the tongue, and certain viscera support the diagnosis (see *Zeitschrift für Fleisch- und Milch-hygiene*, 1891, No. 10), but it is often very difficult if separate pieces of meat have to be pronounced upon. Horse-flesh and beef are certainly deep red, the former frequently with a brownish cast; mutton is red or dark-red, pork and veal are of a pale colour. The odour is somewhat different (especially on the application of heat), but it is not easy to found a certain opinion upon it.

The fat is better available for a diagnosis; that of the horse is yellow and soft, that of the ox is harder and yellow only in old animals; mutton may be recognised by hard white fat, and pork by soft white fat.

On chemical analysis the different melting-points of the fat (§ 312) give a clue to the origin of the meat, but the fats from different parts of the body of one and the same animal are so unequally fusible that this criterion may often fail. In one and the same ox E. Schulze and A. Reinecke (König, p. 199) found the melting-point of the kidney fat 50°, but that of the fat of the muscles 41 to 42°. In a sheep fluctuations of 52 to 41° have been observed, and in a pig from 48 to 42·5°. Horse-fat melts at 32 to 37·2°. Every author gives statements which are rather discrepant.

Niebel (*Ueber den Nachweis des Pferdefleisches in Nahrungsmitteln*, Berlin, 1891) has recently shown in a very interesting investigation the high proportion of glycogen and sugar in horse-flesh, and applied the determination of these sub-

stances to the diagnosis of beef and horse-flesh. The determination of glycogen is unfortunately so elaborate an operation, that the method (according to Brücke and Keilz) cannot be here given in detail. The results seem very well adapted for a certain decision in disputed cases. 100 *grm.* of the dry substance, free from fat, contained:

	Glycogen.	Glucose.	Glycogen + Glucose, expressed as Glucose.
Horse	1·5–4·7	0·8–4·9	3·8–6·2
Ox	0–0·8	0·2–1·0	0·3–1·0

Long keeping, smoking, pickling or roasting destroy the glycogen but slightly; young, well-fed horses contain more glycogen than such as are old and worn-out. Even in sausage this method gives certain results if the quantity of horse-flesh added is not too small.

II. *EXAMINATION WHETHER MEAT IS FRESH.*

§ 239. The living muscle has a faint alkaline reaction; lactic acid is formed in abundance in the muscles of the slaughtered animal. On long preservation this acid has a relaxing action upon the meat. Meat which has been hanging or lying for some time offers much less resistance to our teeth than such as has been freshly killed.

As long as meat has an acid reaction there exists no decided putridity. We may therefore regard the test with litmus paper as an important method of ascertaining the freshness of meat. As soon as an alkaline reaction sets in—ammonia and substituted ammonias being formed by the activity of schizomycetes—putrefaction has already reached an advanced stage.

The smell and taste are altered in a well-known manner. The sense of smell gives the earliest and most trustworthy indication of incipient decomposition.

Eber (*Archiv f. Wiss und Pract. Thierheilkunde*, xvii., 1891) recommends the formation of ammonia by putrefaction to be observed by the approach of a glass rod moistened with hydrochloric acid (cloud of sal-ammoniac). As strong hydrochloric acid gives off fumes in the air, he pours into a

small glass cylinder a few cubic centimetres of a mixture of 1 part hydrochloric acid and 3 parts alcohol + 1 part ether. The glass is stoppered and shaken, so that its sides are moistened. A fragment of the meat stuck upon a wire is then introduced without touching the sides of the cylinder. A cloud appears only if NH_3 is present.

The colour of fresh meat is light reddish-grey to dark brownish-red; if decomposing it changes to a greenish-grey or greenish-violet. The change of colour is to be seen first on the specular part of the sinews. The consistence of fresh meat is firm; on commencing putrefaction it becomes somewhat soft; the surface often shows smeary deposits of bacteria.

Kraus has made an especial study of the species occurring on the outside of meat. He found fifty-one species, none of them pathogenic, but one species very similar to *Bac. coli communis* and to Gaertner's *Bac. enteridis* (*Zeit. f. Fleisch- und Milch-hygiene*, 1890–91, part 5).

According to Gaertner, meat three days old contains bacteria only in the outer margin zone; meat ten days old and quite putrid to the depths of 1 centimetre is quite permeated by bacteria; the blood-vessels are, however, free from microbia if the meat has been obtained from a healthy animal. The examination must take place on dyed microtome sections. Occasionally also plate-cultures with exactly known quantities of an infusion of finely ground meat are useful, enumerating the colonies.

In venison epicures accept a degree of putrefaction (*haut goût*) which hygiene cannot approve. I cannot lay down a limit of toleration.

Occasionally there occurs luminous meat, fishes, &c. With us this light is produced chiefly by the greenish phosphorescent *Bacterium phosphorescens* (Fischer), which spreads over the meat (see § 84). Very dilute plates on gelatine containing 3 per cent. of common salt yield a pure culture. Plate-culture is rendered difficult by the circumstance that *Bacillus fluorescens putidus* is antagonistic and interferes with the growth of *Bacillus phosphorescens*, and numberless septic germs are always present upon meat or fish along with the luminous bacilli. (See also Beyrinck, *Centralblatt f. Bakteriologie*, vii., p. 338.)

III. *EXAMINATION WHETHER MEAT HAS BEEN OBTAINED FROM A SOUND OR A DISEASED ANIMAL.*

§ 240. If in this research we restrict ourselves to a scrutiny of the muscular flesh by means of the unaided senses, it will often prove impossible to detect the flesh of unhealthy animals, much more to diagnose the disease. Hydatids and cretified trichinæ are certainly detected by an experienced observer, and meat infiltrated by water, traversed by extravasated blood, having the colour of gall or a blackish-red (from imperfect bleeding) will be recognised. But we cannot ascertain much more.

For a decisive judgment in difficult cases we absolutely require to know the condition of the skin and the intestines, or rather a skilful examination of the entire slaughtered animal, followed up by a microscopic or bacteriological investigation according to the methods given in § 39, &c. In many cases the inoculation of experimental animals with particles of the flesh supplies additional data.

The diagnosis of all the different diseases of animals can of course not be here explained. In as far as they are infectious they are closely analogous to human diseases. Here will be merely given a review of the most important diseases occasioned by animal and vegetable parasites, since these possess almost exclusively a prominent importance from the hygienic point of view.

A. Animal Parasites.

§ 241. The majority of the animal parasites hitherto known are of considerable size, whence their examination involves no especial difficulty, always supposing that the parasite does not occur too sporadically.

1. TRICHINÆ.

An experienced eye can recognise trichinæ—especially when cretified—with the lens, though this procedure is always uncertain, and a microscopic examination should not be neglected. For inspection we cut at least 6 to 8 sec-

tions of 1 *cm.* in length from the meat in question, using a curved pair of scissors. These sections are cut in the direction of the fibres, selecting as far as possible the vicinity of the parts where the muscles are attached to the bone, and pushing the place to be cut gently forwards.

If the entire carcase is available the trichinæ are sought for at their favourite stations: the muscles of the diaphragm, the belly, the neck, the eyes, the root of the tongue, the larynx, and in the intercostal muscles. Chatin has recently found trichinæ both free and capsulated in the adipose tissue, which disagrees with earlier experience.

The sections of meat are then laid side by side upon a port-object, covered with another port-object, and pressed together so as to obtain thin, translucent preparations. The sections must be so thin that on slight pressure they become ½ *cm.* in breadth. The examination is effected with a magnifying power of 30 to 80 diameters, though a rapid preliminary view is best taken with 20 to 30 diameters.

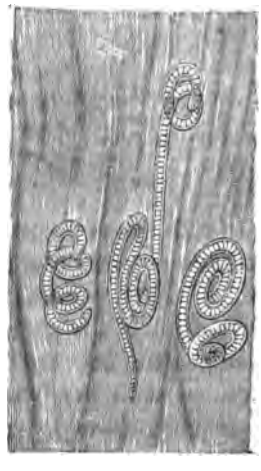

FIG. 89.—Young Muscle Trichinæ, according to Heller.

The image presented by trichinæ in a muscle is different according to the length of time which has passed since the invasion of the trichinæ.

When the embryo trichinæ are born in the bowel they are only from 0·1 to 0·15 *mm.* in length; soon after birth they perforate the coats of the bowel[1] and migrate into the muscles of the body; quite young muscle trichinæ may have a length of 0·3 to 0·4 *mm.* After they have penetrated into a muscular fibrilla, the worms which were previously straight grow in about fourteen days to the length of from 0·6 to 1 *mm.* and the breadth of

[1] The pig shows symptoms of disease only if abundantly infected, inflammation of the bowel and muscular irritation combined.

0·05 *mm.*, whilst the body is curved spirally. By degrees, in the course of some weeks, there is formed by the reactive growth of the interfibrillar connective tissue a capsule of about 0·4 *mm.* in length, oval in form, but subsequently of the shape of a lemon, around the worms, which are now completely at rest. After some months drops of fat appear at the poles of the capsule in which there gradually appears a continually increasing deposit of lime. If after about 1½ year the capsule conceals the form of the trichina the latter can be made visible by adding a drop of acetic acid, when the lime is dissolved with an escape of carbonic acid. If, as it often happens, the trichinæ are dead and decayed, the stout homogeneous capsule after removal of the lime admits of an accurate diagnosis.

FIG. 90.—Capsulated Muscular Trichinæ.

When weak, stale vinegar has been used to remove the lime it has happened that the so-called "vinegar eels" (from 1 to 2·5 *mm.* in length) have found their way into the preparation and have occasioned errors. But trichinæ are never so freely mobile and are otherwise very different on close scrutiny.

In order to decide whether the meat in question contains living or dead trichinæ, we require to observe distinct movements. Even within the capsules in a warm room distinct movements of the anterior extremity are observed in recent trichinæ, and become more lively if we seek to open up the capsules with preparing needles and heat the port-object slightly (to above 40°); the application of an acid stimulates the creatures to rapid but transient movements.

If a certain decision cannot be arrived at in this manner rats and rabbits are fed on the suspected meat. After the lapse of three weeks, if the parasites are living, the muscles are found pervaded by young trichinæ.

In general trichinæ often die spontaneously in the course of years, but cases have been published where they have remained living for 7, 8, 10¼, 11¼, 13, and, on one occasion, 24 years. See Dammann.

(*Deutsche Zeitschrift f. Thiermediz*, iii. 92). According to Gerlach they perish at a temperature of 56°, which in the interior of large pieces of meat is attained only after prolonged roasting.[1] According to Fiedler a heat of 62 to 69° is required to kill trichinæ. According to Leuckart they are little injured by freezing; three days' exposure to −25° left muscular trichinæ uninjured.

On salting they perish quickly only in the superficial layers; at the depth of from 2 to 3 *cm.* only after some weeks; they were still alive in the interior of a ham which had been salted two months previously. In putrid meat they survive for weeks.

Smoking and drying greatly injure trichinæ. In well-smoked hams they are usually dead, as in the majority of American hams in which trichinæ have been found remarkably often. Latterly the proportion of trichinæ has been reduced in consequence of stricter regulations. In Prussia about one pig in 1800 or 2000 is trichinised.

Besides in pork, trichinæ have been found in the flesh of rats (from 6 to 8 per cent. of all rats are said to be trichinised), more rarely in mice and hamsters, occasionally in beasts of prey—cat, dog, fox, badger, bear. According to Johne the examination of sausages for trichinæ can be carried out with some degree of accuracy only if at least three to four thin sections per kilo are cut out of the sausage at different places. Harpooning out morsels from the sausage is, in his opinion, quite insufficient. Consequently a rational search for trichinæ is practicable only before the mass has been stuffed into the skins.

§ 242. Occasionally there occur parasitic worms which have an approximate similarity to trichinæ; the characteristics of the latter are:—

1. The shining, non-striated, lemon-shaped capsule.

2. A thin anterior and a thicker, rounded, posterior end of the body. The œsophagus, except at the head extremity, is surrounded as far as the middle of the worm with a thick

---

[1] The juice of meat has a different appearance according to the temperature to which the meat has been exposed.

Below 56° the juice is red and turbid.
From 56 to 60° ,, clear, light red.
„ 70 to 72° ,, brownish red.
„ 75 to 80° ,, yellowish.

At 65° the colour of meat changes from red to grey.

coating of large cells (the "cellular body"), which is almost entirely wanting in other worms which might have come in question.

3. The residence in the muscles.

A series of larval forms of worms of the families of Ascarides, Strongylides, and Filariæ occasionally occur in capsules which have a remote resemblance to the capsules of the trichinæ, but they are found much more frequently in the viscera than in the muscles (the latter in fishes, moles, and mice). In all the characteristic cellular body is wanting, and they possess a conically pointed tail. The Ascarides have also a boring-tooth at the head-end.

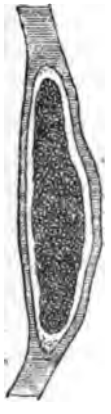

Fig. 91.—Miescher's Tube. (According to Leuckart, 1:50.)

The young form of *Trichocephalus dispar*, a cylindrical worm common in the bowels of man and of the domestic animals, greatly resembles a trichina, but it has a cellular body, which extends to the posterior third part of the worm: in its trichina-like stage it is from three to four times smaller than the intestinal trichinæ. It is never met with in the muscles.

Miescher's Tubes, Psorospermian Tubes, Rainey's Bodies.—We find not uncommonly, in the longitudinal direction of the muscular fibres, lancet-shaped, darkly granular tubes (length up to 10 *mm.*, breadth 0·2 *mm.*); they are found in the muscles of swine, oxen, sheep, and horses, which under a low magnifying power have a certain resemblance to trichinæ (Fig. 91); but in them every indication of a worm is absent. We find instead, with a magnifying power of 300 to 400 diameters, that the contents of the tube consist of lentil-, bean-, or half-moon-shaped structures, densely crowded together, some of them, again, being enclosed in a thin-skinned globe. The tubes lie in the sarkolemma of a muscular fibre.

Analogous structures occur in masses in bags, which hang freely in the œsophagus, especially of sheep and goats, having their point of attachment to the muscles of the œsophagus. For details on signification of these organisms see § 93. 2.

2. HYDATIDS.

§ 243. The flesh of numerous animals harbours hydatids—the non-sexual, youthful form of tape-worms, which are developed from the hydatids when they find their way into the intestinal canal of another suitable animal. The following table gives a conspectus of the species:—

Hydatids.		Tape-Worms.	
Host.	Name.	Name.	Host.
Swine, man.	Cysticercus cellulosæ.	Taenia solium.	Man.
Ox (experimentally, goat).	Cyst. taeniæ saginatæ.	Taenia saginata seu medio cannelata.	Man.
Sheep.	Coenurus cerebralis.	Taenia coenurus.	Dog.
Ox, man, sheep, swine	Echinococcus hominis et veterinorum = Ech. polymorphus.	Taenia echinococcus.	Dog.
Hare, rabbit.	Cyst. pisiformis.	Taenia serrata.	Dog.
Ruminants, swine.	Cyst. tenuicollis.	Taenia marginata.	Dog.
Mouse.	Cyst. fasciolaris.	Taenia crassicollis.	Cat.
Trichodectes canis (dog-louse). According to more recent authors (Grassi, Lutz), this intermediate host is the rare exception; the Taenia is often developed from the egg without intermediate host.	Cryptocystis trichodectidis.	Taenia elliptica seu canina.	Dog; rare in man. According to recent inquirers, identical with Taenia cucumerina of the cat.
Pike (Esox), perch (Perca), burbot (Lota), Salmo umbla Trout; (Trutta vulgaris et lacustris), (Thymalus vulgaris).	Cysticercus of Bot. latus.	Botryocephalus latus.	Man.

The sheep harbours no hydatids pathogenic for man.

§ 244. The hydatid of *Taenia solium* (formerly known as *Cysticercus cellulosæ*) forms in pork, and that of *T. saginata* in beef, in the adult state, roundish or oval bladders, from the size of a pea to that of a cherry, translucent, and filled with a watery liquid: these bladders are found not only in the muscles but occasionally in other parts of the body. If gently pressed and rolled between the fingers they feel compact, and with a little skill it is almost always practicable to evert the neck-process, together with the head (which in

the developed hydatid is visible as a white opaque spot) out of its receptacle.[1]

If an entire animal has to be examined, we test first those favourite spots of the Cysticercus which are accessible for scrutiny—the root of the tongue (swine), the heart and masseter muscles (ox). In the former locality the hydatids may often be seen in the living animal. Hydatids on the surface of a piece of meat, which have been dried up and thus rendered less distinct, may be rendered visible again by steeping in weak acetic acid (Laboulbène).

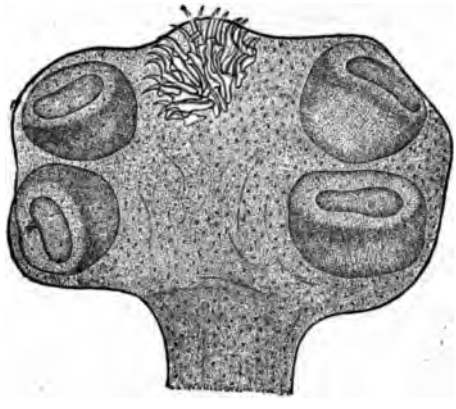

FIG. 94.—Head of *Taenia solium*.

If the hydatids (Fig. 94) are numerous (from 10,000 to 20,000 have been found in one pig), the macroscopic diagnosis is very easy. Sporadic hydatids may naturally be overlooked, even in the most careful scrutiny of meat, as cutting up the muscles for examination of course injures the appearance of the meat.

For an accurate diagnosis the head[2] of the Cysticercus is everted (Heller), cut off along with the shortest possible

[1] A confusion with fat-lobules which occur in the interfibrillar connective tissue can be avoided by touch. In doubtful cases the microscope must decide.

[2] Thirty-two days after the infection of an animal with tapeworm-eggs, the hydatids are the size of a hemp-seed, with an indication of the position of the head: after forty-six days they are the size of a pea; after sixty days they are perfectly developed; after two and a half months they are capable

piece of the neck, and placed in glycerine with gentle pressure under a magnifying power of eighty diameters. We now search for the four sucking-cups of the worm, and in case of the tapeworm of swine we search for the very characteristic double garland of hooks, consisting of twice sixteen hooks. A single hook, distinctly seen, establishes the diagnosis. We must also note the rounded or oval calcareous corpuscles which are everywhere imbedded in the tissue of the head, which disappear on the application of acetic acid, and may assist in the diagnosis in doubtful cases (Ostertag). If there is before us only a single hydatid, which may have been calcified or boiled, the diagnosis may become difficult, as also if the Cysticerci are very young, and at the same time very numerous, or are even dead (the appearance then reminding us of tuberculosis). In Prussia there is 1 hydatised (measly) pig to 324 healthy individuals; in Berlin, 1 to 124.

In the Cysticercus of the ox, which is in Germany less common than in swine,[1] the hooks are wanting.[2] The Taenia proceeding from them is also known to be devoid of hooks. Especial attention must here be given to the suction-cups. The Cysticercus of the ox is also devoid of a distinctly prominent rostellum, but they possess in its stead a pit-like depression on the surface of the head (so-called frontal suction-cup).

The hydatids of oxen and swine are not well able to resist external agencies. Their vitality is always extinguished fourteen days after the slaughter of their host. Leuckart never obtained a positive result in dietetic experiments with quite fresh ham prepared from hydatidous meat. According to Perroncito a hydatid prepared out died on immersion for one minute in water at 50°.

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of becoming a tapeworm in the intestines of another animal. In three to six years the Cysticercus dies and is calcified.

[1] The hydatid of swine is decidedly more common, yet in some districts *Taenia mediocanellata* is much more common in man than *Taenia solium*. The bad habit of eating raw pork is declining, but the consumption of raw beef is increasing. In Berlin Ostertag found on careful examination only one hydatidous animal among 400, in 1889 and 1890.

[2] Small points are present only in the earlier stages of development, but they subsequently disappear without further growth.

§ 245. Echinococci, *i.e.*, the hydatids of the small three-jointed tapeworm of the dog (*Taenia echinococcus*), which is altogether only 4 to 6 *mm.* in length occur, very frequently in some districts as thin-skinned water-vesicles, especially in the liver and lungs of oxen, sheep, and swine. They are more rarely found in other organs (the muscles included), none being entirely safe from them.

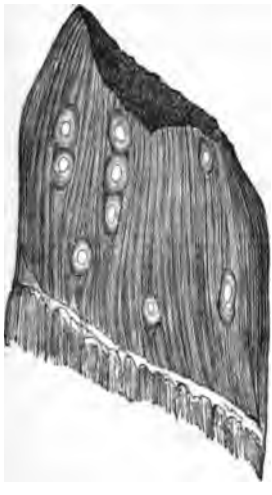

FIG. 95.—Pork with Hydatids according to Birk-Hirschfeld.

Natural size. The head-processes of the hydatids are visible.

In South Germany this disease is the third in point of frequency among those observed on slaughtering. In Iceland 28 per cent. of dogs suffer from *Taenia echinococcus*, and from 2 to 25 per cent. of the inhabitants have the cysts of Echinococcus; 7 per 1000 of the bodies dissected at the Pathological Institute at Berlin have suffered from the same cause.[1]

The mature cysts of Echinococcus present the following appearance: In a fibrous capsule, more or less substantial, lies the cyst, very variable in size (from 1 to 10 *cm.* in diameter), filled tightly with a clear aqueous liquid. The side of the cyst, which is very distinctly stratified on its (optical) section, presents a very characteristic aspect, lined with a ciliated epithelium. In the cyst there is always found in young animals, and more rarely in aged animals, merely the above-mentioned liquid; generally there are suspended to the side of the cyst the so-called brood-capsules, pullulations of the parenchyma, into which the epithelial layer extends downwards.

[1] In Australia tapeworms and their earlier stages have become a fearful nuisance. Public attention is being drawn to the necessity of absolutely excluding all animals which may be the hosts of these parasites from access to all reservoirs, aqueducts, gathering grounds, and feeders which are connected with the water-supply of cities.—*Editor.*

By growth and investigation there then appear on the brood-capsules the heads of the tapeworms with their rostellum, four suction-cups and their hooks, arranged in two series each of 14 to 25 pieces. From a single brood-capsule there may arise numerous heads (as many as 22). Along with this development of heads there takes place a formation of daughter-cysts, which arise in different manners, and may finally lie either within or without the mother-cyst.

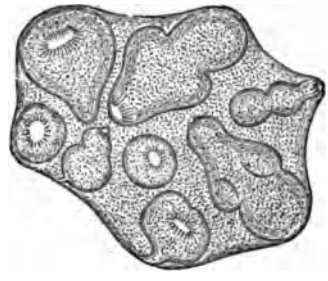

FIG. 96.—Brood-capsule of an Echinococcus with Heads of Tapeworms according to Schmidt-Mültheim.

At the great age which the Echinococci often attain we find occasionally in the interior of the cysts merely detritus, defunct heads with detached hooks, the latter floating freely in the liquid of the cyst.

FIG. 97.—*Scolex echinococcus*, invaginated according to Heller.

The diagnosis is based:

1. In typical cases on the macroscopic appearance of the large cysts, which are in part nested within each other. This character is not always sufficient.
2. On the microscopic detection of the hooks or of the scolices, and the characteristic stratification of the sides of the cysts.
3. On the chemical character of the liquid. It is free from albumen, and consequently does not coagulate on boiling; it contains small quantities of sugar, inosite and succinic acid.

Fishes have been hitherto but little examined for parasites. In botryocephalic regions (Baltic provinces, Western and Southern Switzerland, Northern Italy) the corresponding Cysticercus has often been frequently found in the species mentioned on p. 11.

3. SOME ANIMAL PARASITES OF LESS IMPORTANCE.

I. Worms.

I. Cestodes.

§ 246. 1. *Coenurus cerebralis* is the cystic worm of *Taenia coenurus* of the dog. It is 30 to 40 *cm.* in length, and is frequently found in the brain and in the spinal cord of sheep. Young animals only are susceptible; old individuals enjoy immunity. It is rarer in the ox, and in man it is absent. The cysts which are developed and which reach their full size in two to three months (varying from the size of a pigeon's egg to that of a hen's egg), are provided on their internal side with numerous (up to 500) heads, which may be everted outwards, and which possess hooks.

2. *Taenia expansa.*—A large tapeworm which often appears in masses in the bowel of young sheep (tapeworm disease), and occasions a cachectic condition. Intermediate host unknown.

II. Nematoda (Round-Worms).

3. *Ascaris megalocephala.*—The large-headed round-worm or thread-worm often occasions intestinal obstruction in horses, and more rarely perforation. In oxen *Ascaris lumbricoides* often occurs.

4. *Strongylus armatus.*—The embryos are introduced into their host (horse) when drinking water. The larvæ live in aneurisms of the mesenteric arteries; on migrating thence they suck themselves fast to the bowel and become sexually mature ($\frac{1}{4}$ to 12 *mm.*)

Strongylus tetracanthus encysts itself in the submucosa of the bowel of horses.

5. *Strongylus contortus* (male from 1 to $1\frac{1}{2}$; female, 3 *cm.* in length) establishes itself in masses in the abomasus of young sheep and occasions there a violent inflammation. The "red stomach-worm disease" occasions emaciation and often death.

6. *Strongylus filaria* (male from 2 to 3 and female from 8 to 9 *cm.*), white and filiform, produces in the sheep and the goat (as do *Strongylus micrurus* in the ox and *Strongylus paradoxus* in the swine), in the respiratory organs which it infests, bronchitis, lobular pneumonic foci, and, finally, nodes of connective tissue inclosing the worms. Sheep often die from the parasites occurring in masses. Swine and cows certainly suffer, but generally survive the affection. The lungs are diseased to a very disgusting extent. Among game also (roe, hare, &c.) species of Strongylus effect devastations. Similar is the effect of *Pseudalius capillaris* in the sheep and the chamois. (See Arthur Müller, *Nematoden der Säugethierlunge. Deutsch. Zeitsch. f. Thiermedicin*, 1889.

7. *Echinorrhynchus gigas.*—This powerful worm, with its proboscis beset with thorny barbed hooks, bores its way into the intestinal mucous membrane in swine (rarely in man), occasioning there inflammation and waste. Its early form is introduced into swine by the larvæ of insects.

III. Trematoda (Flukes).

§ 247. 8. *Distomum hepaticum* and *lanceolatum.* Two species of flukes are often found in the liver of sheep and oxen (more rarely in goats and swine), less frequently in the lungs, and extremely rarely in the muscles, the subcutaneous tissue, &c. In one liver there may be contained from 500 to 1000 flukes. *Distomum hepaticum* is from 1½ to 4 *cm.* in length, and from ½ to 1 *cm.* in breadth. The accompanying figure shows more plainly its form. The colour is a leather-brown; it occurs chiefly in the enlarged and cretified biliary ducts and also the parenchyma of the liver, which is often destroyed to a great extent after being first attacked with interstitial hepatitis, perihepatitis, and hepatoscirrhus. On the surface the worms are mostly beset with warty points. From the ova of the distoma there are developed in water ciliated embryos which undergo in small water-snails (*Limnæus truncatulus*) a farther development to larvæ. In the larvæ occurs their development to a second generation of tubular larvæ (*redia*), in which there appear tadpole-like motile organisms (*cercaria*), which are encysted either in the snails, or more frequently whilst adhering to the grass after leaving them, and are swallowed by grazing sheep, &c.

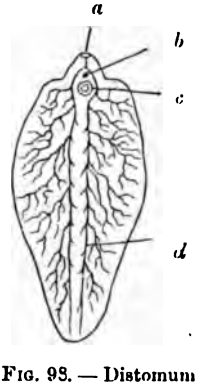

Fig. 98. — Distomum hepaticum 1½ times its natural size.

a. Anteria suction-cup.
b. Porus genitalis.
c. Abdominal suction-cup.
d. Division of the bowel.

The embryos pass through the biliary ducts into the liver, and, in rare cases, into the systemic circulation. In man Distomum ranks among the rarest parasites.

The presence of numerous flukes brings on in consequence of the consecutive inflammation of the liver, anæmia, ascites,

and severe sickness in sheep, very rarely in man. The ox is very slightly sensitive to the destruction of the liver by flukes. See Schaper, *Deutsche Zeitsch. f. Thiermedicin*, 1889. A complete monograph. Latterly there has often been found in the muscles of swine a small Distomum (size of an encysted trichina), the meaning of which is obscure.

Distomum lanceolatum is much smaller, from ½ to 1 *cm.* in length and from 1 to 3 *mm.* in breadth, and is in many districts very pernicious. It is diffused among domestic animals, and has not yet been detected in man. Its intermediate host is not yet known with certainty; species of Helix are suspected.

2. Articulata.

§ 248. 9. *Pentastoma denticulatum*, the flat white larva of *Pentastoma taenioides*, about ½ *cm.* in length, is often found encysted in the abdominal glands and the intestinal coats, or free in the peritoneal cavity and in the respiratory passages of sheep, oxen, and other phytophagous animals. The worm-like larva is not a worm, but an acaroid creature (family of Acarinæ), and has a body composed of about eighty segments, covered with thorns, and four or six feet with double retractile claws.

The larvæ, which appear to be generally introduced through the respiratory passages, are developed in the nasal and pharyngeal cavity of the Canidæ, and sometimes of man, forming parasites from 2 to 13 *cm.* in length, having ninety joints, broad in front and pointed behind; they occasion violent irritation of the mucous membrane, and sometimes of the brain. The ova, which are produced in masses, infect plant-feeders, and occasionally man.

10. *Oestrus ovis*.—The young larvæ of the bot-flies are deposited by the female near the nostrils of sheep; they creep into the cavities of the nose, the forehead, and the jaws, grow for three-quarters of a year, becoming grubs of from 2 to 3 *cm.* long, with two large, claw-like, oval hooks and eleven yellowish brown segments. When they migrate, they occasion in slight cases catarrh of the mucous membrane, in more severe cases cerebral symptoms, or even death (spurious staggers). Other species of Oestrus may become hurtful by the development of their larvæ in the stomach of animals, or in cutaneous boils.[1]

[1] Certain species of Calliphora and Lucilia, which normally prey upon carrion, occasionally become parasitic. Of these the screw-worm of Texas is the most dreaded. According to Kirby and Spence, quoted by Westwood ("Classification of Insects," ii. 569), there have been many cases of these species depositing their eggs in the wounds of persons sleeping in the open air. —*Editor.*

11. It may be mentioned that the following parasites may be transferred from the skins of other animals to man :—

Sarcoptes scabiei communis = *Sarcoptes major*, Gerlach = the large acarus of the itch. Lives upon horses, dogs, sheep, and goats.

Sarcoptes minor, F. and G. Lives on cats and rabbits.

Dermatophagus and *Dermatocoptes* are transferred to man only temporarily, and always perish quickly.

Dermanyssus avium (blood-sucking bird-tick). Rare on man.

Leptus autumnalis. The harvest mite or tick.

Demodex (Acarus) folliculorum. Occasion severe skin disease in dogs; harmless to man.

B. Vegetable Parasites.

§ 249. Hitherto we have had merely to test for schizomycetes. Only the fewest bacterial diseases of animals can be detected by an examination of the flesh; it is at most unusually pale, infiltrated with saline secretions, or traversed by extravasated blood. A diagnosis is often practicable for an experienced observer by the state of an entire dissection. A bacteriological examination conducted according to the methods given in § 64 will be decisive for the diagnosis. Sometimes a smear-preparation is sufficient, sometimes section-preparations have to be got ready, but especially cultures and experiments on animals.

The most important diseases to be considered are :—

1. *Tuberculosis* (pearl-disease).[1]—Very common in oxen, rare in calves, very rare in sheep, goats, horses, cats, and dogs; rather common in swine and in poultry. In the ox, tuberculosis generally takes a chronic course with the formation of small and large sarcomatous, granulated tumours, which have their seat in the serous membranes (pleura, peritoneum, the coating of the diaphragm), but also in the lungs, the lymphatic glands, and all the other viscera. These luxuriant growths are at first soft, but may afterwards calcify or shrivel up like connective tissue; true tyrosis is rare.

[1] In Bavaria about 5000 tuberculous oxen are yearly slaughtered; in Baden about 1 per cent. of the cattle slaughtered are thus affected, at Augsburg 2·2 per cent., at Munich 2.7 per cent., at Berlin 4·5 per cent., at Copenhagen 6 per cent., at Frankenberg 16·6 per cent., and in Zittau actually 22·4 per cent. Swine are rarely infected (about 1 in 4000 in Baden), young calves very rarely (1 in 24,000).

Sometimes such growths are found in an otherwise healthy and well-nourished animal in a single locality, as a symptom of a purely local disease. In other cases the entire animal is pervaded with nodes (the muscles excepted); there occur at the same time in the lungs pneumonic infiltrations with a tendency to tyrosis and purulent liquefaction, so that the type of phthisis may be perfectly developed. Less common is tuberculosis of the bowels, the genitals, and the udder, &c.; acute miliary tuberculosis is rare. In advanced stages of the generalised disease the animals become emaciated, the flesh is watery, and the fat disappears.

The pearly nodes are very characteristic; in doubtful cases the bacillar tubercles must be recognised by staining smear- or section-preparations, or preferably by introducing small particles into the anterior chamber of the eye, or into the peritoneum of rabbits, when tubercular iritis or peritonitis appears in about four weeks. For particulars see §§ 46, 51, 74, 75, and 86.

A pseudo-tuberculosis, observed first by Eberth and recently by A. Pfeiffer (*Ueber die bacilläre Pseudotuberculose der Nagethiere*, Leipzig, 1889), which occurs in rodents on inoculation and feeding (other animals of different classes are not susceptible). The exciter is a bacillus, twice as long and three times as broad as Koch's tubercle bacillus. It can easily be cultivated upon gelatine, which it does not liquefy, and is preferably stained with methylene blue. The disease spreads especially along the lymph-passages; the nodes and nodules, which appear specially in the abdominal organs, shelter the microbia in luxuriant heaps. The macroscopic pathological-anatomical aspect is very similar to that of tuberculosis; the differential diagnosis is very easy, according to what has been said. This destructive disease of rabbits and guinea-pigs has been frequently studied in France.

2. Glanders = *Malleus humidus* = morve.

Characteristic alterations in the flesh are absent. Among animals, horses are almost exclusively attacked; goats are rather susceptible to this infection, sheep less so, swine scarcely ever. Glanders may be communicated to dogs and cats. Oxen are not susceptible. See § 86.

The three main seats of chronic glanders are:—

1. The *nasal septum*, and in general the mucous membrane of the nose. Round-celled infiltration, with necrotic ulcerated disintegration; lardaceous basis, with a tendency to the formation of pale radiating scars. At the same time there occurs nasal catarrh, often on one side only. Infiltration of the lymph-glands, especially in the neck.

2. *Lungs.*—Partly disseminated infiltration in the form of whitish

nodules (acute form), partly larger nodes resembling sarcoma (chronic form). The granulation tumours may become caseous, suppurate, become ichorous, and shrivel up like connective tissue. At the same time there occur pneumonic infiltrations. The pulmonary affections are very rarely absent, and often indeed are primary.

3. *Skin.*—Nodes, surrounded by swollen lymph-glands, lie at different depths beneath the skin; they are afterwards resolved into pus, and form tumours, which perforate the skin. Nodes occur also frequently on the internal organs, especially the spleen.

In acute glanders the most prominent feature is a serous-purulent hæmorrhagic inflammation of the mucous membrane of the respiratory organs, with formation of ulcers and suppuration, but there may also occur affections of the lungs and skin.

The important diagnosis of chronic glanders is often difficult to effect during the lifetime of the subject, in spite of all expedients. Staining the bacilli in smear-preparations requires a prolonged application of Loeffler's alkaline methylene blue. For cultures, especially on potato, see § 86. For a check by inoculating animals it is recommended to select male guinea-pigs. On inoculating in a fold of skin there appear in succession ulcers of the skin and swellings of the lymph-glands near the place of the operation, inflammation of the testes, inflammation of the joints, nodes of the skin and of the nasal mucous membranes. Death generally ensues in four weeks. Strauss recommends inoculation of the peritoneal cavity of male guinea-pigs; after twenty-four to forty-eight hours there occurs a typical swelling of the testes.

3. *Anthrax* (splenic fever).—This affection is common in oxen and sheep, rare in horses and swine. The spleen is strikingly enlarged, brittle; very often there is found a hæmorrhagic necrotic inflammation of the bowel and a somewhat extended sanguineous-gelatinous saturation of the connective tissue of the cutis, frequently carbuncular inflammations of the skin. Lungs, liver, and kidneys hyperæmic, and traversed by ecchymoses; in the acutest cases an almost normal section may be observed. The muscles are often quite unchanged, though now and then a dark colour and interspersion with hæmorrhages may be observed. Even when only muscles are available, it will be possible to find the bacilli of anthrax on the microscopic examination of stained smear- or sectional-preparations (spores are always wanting); small quantities of blood or of flesh inoculated subcutaneously in rabbits, guinea-pigs, or mice produce in them fatal anthrax.

In a case in which a man became fatally diseased after eating ham, Tavel demonstrated in the patient a microbe morphologically identical with that of anthrax, but which did not kill mice until thirty-one days. Anthrax is also a very rare affection in swine; the case is not quite clear (*Centralblatt f. Bd.*, ii. 281).

4. *Charbon symptomatique.*—A pernicious disease of oxen, sheep, swine, and horses. The septicæmic disease proceeds from deep injuries of the skin or mucous membrane. At the point of infection there is sanguineous-gelatinous infiltration of the cellular tissue of the hypoderma; the adjoining muscles are coloured brown or black; the entire prominent tumour is interspersed with gas-bubbles, which crackle or rustle on pressure. Sanguineous-serous efflux into the hollows of the body and the retro-peritoneal tissue, frequently hæmorrhages in the serous membranes. Spleen normal. A certain diagnosis may be effected by means of the short characteristic bacilli (§ 88). Rabbits and mice are almost non-susceptible; guinea-pigs perish invariably if small traces of the muscle are inserted under the skin.

5. *Malignant Oedema.*—A rare disease in cattle. Not epizoötic, but widely distributed. State of section as in charbon symptomatique; the development of gas is not absent.

A certain diagnosis is obtained by the detection of the characteristic bacteria (see § 88) in the œdema and the organs; during life they are not present in the blood, but they become distributed in it after death. All the animals commonly used for experiments are susceptible, even rabbits (a distinction from charbon symptomatique).

6. *Pulmonary Disease of Oxen.*—Interstitial infections, pneumonia with secondary hepatisation, and pleuritis. The character of the disease approximates to human pneumonia; the tendency to exuberant growth of the connective tissue and shrivelling of the tissue gives the lungs, if the animal is killed in the later stages of the disease, a peculiarly compact, characteristic structure. The ejection of necrotised portions is also not wanting. No changes are found in the rest of the body. The micrococci cultivated by Poels and Nolen from the lungs in this disease are round and have sheaths; they are frequently arranged in short series, and in a gelatine plunge-culture they resemble Friedländer's pneumonia microbia, but all the cultures become yellow. Injection into

the lungs reproduces the disease in oxen, dogs, rabbits, and guinea-pigs.

Among the pernicious febrile diseases of swine, attended with a spotty redness of the skin, and formerly confounded as the erysipelas of swine, three are now distinguished:—

7. *Bacillary erysipelas*, swine erysipelas in the stricter sense. A septic, intensely feverish disease tending to hæmorrhages, violent gastro-enteritis, swelling of the spleen and all the lymphatic apparatus, parenchymatic inflammation of the organs. A certain diagnosis is founded on the pure cultivation of the fine bacillus which Koch described as the cause of the septicæmia of mice (see § 84). Animals suitable for inoculation: house-mice (not field-mice), white rats, rabbits become diseased slowly, and guinea-pigs not.

8. *Swine-plague.*—The most prominent feature is a cheese-like, necrotic multiple, lobular pneumonia, accompanied by parenchymous degenerations in the liver, kidneys, and heart. The spleen, the bowel, and the lymphatic glands are not generally much modified. (See § 84.)

Mice and rabbits die quickly, guinea-pigs and rats are not easily infected.

Identical, or nearly allied bacteria, produce the game- and cattle-disease (Bollinger), chicken-cholera and the pulmonary disease of horses (Kitt, Hüppe), but the appearance of the diseases is very different.

In oxen the exanthematic form prevails, strong swelling of the skin, enormous gelatinous, subcutaneous infiltration of the connective tissue, similar changes in the mucous membranes of the mouth and tongue and their submucous membranes. Hæmorrhages everywhere. Spleen normal, as also the blood. Hæmorrhagic enteritis rarely absent.

In game there predominates the pectoral form. Jelly-like interstitial pneumonia, pleuritis, pericarditis.

In poultry (chicken-cholera) the prominent feature is hæmorrhagic enteritis with desquammation of epithelium and an abundant efflux of liquids. There occur hæmorrhages into the flesh of the heart, and croupy hæmorrhagic pneumonia. The flesh is often quite normal, at other times of a dark reddish grey, and undergoes lardaceous degeneration. The most certain diagnosis is obtained by introducing the blood into the pectoral muscles of a pigeon, which perishes in from twelve to fourteen hours, with a yellowish, caseous infiltration at the place of inoculation.

9. *Swine disease* (hog-cholera).—A necrotic enteritis, predominantly typhic. Very destructive in America, England, and Sweden. The exciter of the infection is not known with certainty.

10. *Pyæmia and Septicæmia.*—In connection with injuries, but especially after parturition, pyæmic affections often occur cryptogenetically. As in man the condition found on dissection is very various. In the pyæmic forms there are especially multiple (embolic) foci of suppuration present in the body (in the different organs), along with hæmorrhages on the serous membranes. In the forms generally known as septicæmia every symptom may be wanting except a dull swelling and fatty degeneration of most organs (heart, liver, spleen, &c.).

The most common form is the septic inflammation of the uterus and udder of cows, the septic inflammation of the umbilical cord in calves, &c., and the consequent multiple inflammation of the joints. The characteristic symptom is here a yellow gelatinous infiltration at the tarsial articulation, and the efflux into the joint of a yellow exudation. But affections with the aspect of septic gastro-enteritis play here an important part.

In all cases a number of micro-organisms are concerned in these processes, the most important of which seems to be *Bacillus enteritidis.* (See § 84.)

Another organism approximating in many respects to the typhus bacillus was isolated by Gaffky and Prak from hams of horse flesh, which had occasioned a certain dangerous illness and one fatal case (*Arb. aus den Kais. Gesundheitsamt.*, vol. vi.). The microbe produced in animals experimented upon, whether subcutaneously or by way of the stomach, diarrhœa, emaciation with fever, paralysis of the hinder extremities, and death.

11. *Dysentery in calves.*—Similar to human dysentery, attacks calves only in the few first days of their lives, and often destroys them in numbers. Its ætiology is unknown.

12. *Diphtheria.*—The diphtheria of calves, according to Loeffler, is produced by large bacteria with an undulating curvature. (Concerning the common diphtheria of poultry, and especially of pigeons, see §§ 84 and 93.) Notwithstanding the external similarity of the various animal

diphtherias with the typical human diphtheria (§ 86) the diseases are ætiologically quite distinct.

13. *Actinomyces bovis.*—In 1877 Bollinger detected as the common cause of a series of tumour-like diseases in oxen the radiating microbe. Between 1870 and 1885, 105 cases have been accurately observed.

Most commonly (50 per cent. of the cases) the microbe produces large sarcomatous growths at the angle of the lower jaw, which, where they come in contact with the periosteum, often coalesce with it. The lardaceous tumour extends into the bone, strongly rarifying its texture; it includes softer insulated portions, containing yellow or yellowish grey glands of the size of a millet-grain. Such growths were formerly characterised as osteo-sarcoma (= wind-thorn = *Spina ventosa*); similar growths in the tongue (29 per cent. of the cases) give rise to the formation of "wooden tongue;" the microbe has also been found near the œsophagus in the lymphatic glands, in the liver, lungs, the thymoid gland, &c. Latterly it has been repeatedly discovered in man as the cause of chronic suppuration. For its microscopic appearance see § 88.

A second distinct kind of actinomyces has been found by Dunker in pork: *Actinomyces muscularum suis.* The "lawns" are situate in the muscular fibrillæ, and have a great tendency to cretification. Compare Hertwig (*Centralblatt f. Bakteriologie*, i. p. 209). The surrounding flesh is, where the microbe is abundant, generally soft, watery, slippery, and of a pale yellowish grey. Often we merely find chalky concretions which are not easily interpreted.

The animals slaughtered for food are non-susceptible to many human diseases, *e.g.*, typhus, cholera asiatica, diphtheritis, scarlatina, measles, whooping-cough, and malaria.

C. Diseases from Unknown Parasites.

§ 250. 1. *Foot and Mouth Disease* (aphthous disease).—A very frequent infectious disease of oxen, sheep, and swine; more rarely of goats, horses, dogs, and poultry; very rarely of man. The termination is generally favourable. Along with fever there generally occur blisters and tumours on the mucous membrane of the mouth, at the crown, and at the division of the hoof; sometimes pustules occur on the udder. The infection is conveyed by the saliva and the contents of the pustules. In the internal organs there are few changes; sucking calves suffer from aphthæ and erosions in the stomach and the intestinal canal (§ 256).

2. *Rabies* (hydrophobia).—In the rabies of food animals, which chiefly concerns us, characteristic changes are generally absent. The symptoms before death are generally restlessness, inclination to butt, emaciation, paralysis. Death in from four to eight days after the outbreak of the disease.

3. *Sheep-pox.*—Analogous to but distinct from small-pox. In severe cases it is frequently complicated with septic processes.

4. *Cattle-plague.*—Derived from Central Asia, and occasionally decimating horned cattle and sheep in Europe. The essential feature of the process consists in necrotic-diphtheritic insulated deposits in the inflamed intestinal tract from the mouth to the large intestine. The trachea and the nasal cavity present a similar aspect. The lungs are hyperæmic, the liver of a clay colour and brittle. The gall-bladder is very full; parenchymatic nephritis. Fatal to from 90 to 95 per cent. of the cattle, and to about 60 per cent. of the sheep attacked. The death of oxen takes place generally in a few days with great emaciation and violent fever. The cause of the infection unknown. Man enjoys immunity.

IV. *EXAMINATION OF MEAT FOR POISONS.*

§ 251. As far as inorganic poisons are concerned their detection is effected by the methods given under Household Utensils and Requisites; for organic poisons special works must be consulted (see Bibliography under § 95). Thorough chemical training and experience are here necessary for a successful result. An idea of the complication of the investigations, which may be necessary under certain circumstances, may be gathered from § 256.

Poisoning experiments with meat which has been rendered poisonous by ptomaines, or with its decoctions, &c., are very much more promising with rabbits, guinea-pigs, and mice than with dogs and cats; but occasionally positive results have been obtained with the latter animals: they are certainly not susceptible to the ptomaines of *Bac. enteritidis.*

B. The Examination of Meat.

I. Fresh Meat.

§ 252. Hygiene divides fresh meat for convenience into four classes, a sharp demarcation between which is impossible:—

1. Sound meat. Harmless and appetising for man and the lower animals, whether in a raw or in a cooked state.[1]

2. Meat which, whether raw or cooked, is harmless to man and to the lower animals, but which has more or less decidedly disgusting or unappetising properties.

3. Flesh of diseased animals which, whether raw or cooked, is harmless to man, but by which cattle-diseases may be propagated.

4. Meat injurious to man on eating or cutting up.

a. Hurtful only when raw.

b. Hurtful also when cooked.

§ 253. I. Sound meat, harmless and agreeable to man and to lower animals, whether raw or cooked. The distinction between meat of first and second quality is of subordinate importance for hygiene, but it is so practical that I give it here.

As a matter of course the expert in meat subdivides the quality here termed 1*a* into groups of different excellence, according to the race of the beast, its age, its state of nutrition, and especially according to the region of the body from which the part in question is taken. Into these considerations I cannot enter.

1*a*. Meat of prime quality. The flesh of beasts rationally nourished or fattened, which have been killed either in perfect health or affected with the following diseases without their general health or state of nutrition being disturbed.

1. Single organs containing vesicles of Echinococcus or Coenurus, pulmonary worms, Distomum, isolated Miescher's tubes.
2. Single organs displaying pathological changes, *e.g.*, chronic diseases of the heart or neoplasm confined to a single organ.

The diseased organs are to be destroyed according to § 254. Single specimens of Distomum are found in some places in so many livers that they are ignored in deciding upon the meat. In Munich, *e.g.*, no sheep's liver can be found free from Distomum.

[1] Raw meat, however sound and healthy, cannot well be called appetising to the majority of civilised men.—*Editor.*

1*b*. Meat of second quality. Here ranks meat which is deficient in some of the attributes of enjoyable food, or against which slight objections may be raised as to its appetising nature. Such meat is generally sold at a reduced price at so-called free stalls.[1]

1. Meat from beasts which are too old or too lean; from calves which have not yet got eight incisors; from cows or oxen which do not weigh at least 200 kilos.
2. From beasts with localised, scattered, easily removable pearl-nodules; from such in which one or other Echinococcus may have been found in the muscles. Pork containing a few *Actinomyces musculorum suis*.
3. Of animals which have fallen off in condition in consequence of chronic affections of single organs.
4. Flesh of beasts which have been killed from necessity in consequence of recent injuries—the slaughter to take place at latest twenty-four hours after the injury. Any indication of infection (strong swelling, fever, &c.) excludes the meat. The injured organs are to be destroyed.

§ 254. II. Meat, raw or boiled, not hurtful to man or to lower animals, but with more or less pronounced disgusting or non-appetising properties:

1. Meat of intensely unpleasant smell and taste.
   a. Flesh of male breeding animals: bulls, boars, rams.
   b. Flesh of beasts which have absorbed evil-tasting or malodorous substances from their food or from medical treatment, *e.g.*, by the ingestion of camphor, carbolic acid, petroleum, balsam of sulphur, or by feeding on fish or spoiled oil-cake, &c.
2. Flesh of animals which have been fed on loathsome but tasteless offal (*e.g.*, the flesh of horses which have died a natural death). Demonstrable in general only by the evidence of witnesses.[2]

[1] Tables or counters in the markets where meat of inferior quality is allowed to be sold.

[2] In some parts of England pigs are fed on butchers' refuse, blood, &c.—*Editor.*

3. The flesh of unborn or aborted calves, though of healthy mothers. The young of diseased beasts are to be regarded as dangerous to health.
4. The flesh of animals drowned or suffocated in smoke. The meat is then of a dark brownish-red, and saturated with blood. The flesh of animals which have died of apoplexy is similar.
5. Meat which has been improperly treated, *e.g.*, by blowing air into the cellular tissue of the cutis. The air thus introduced and its micro-organisms promote putridity.
6. The flesh of hunted or baited animals. Draught-oxen which have been over-worked, and fat swine which have been over-driven, sometimes perish in a few hours. According to Gerlach the flesh is decolorised, tender, the transverse striation often imperfect, the blood thick, œdema of the lungs, and transudations in the serous cavities. The meat is said to be even injurious to health, though proof is wanting.
7. The flesh of animals which have died a natural death, when it is testified by a veterinary surgeon that it is not decidedly injurious.
8. Meat and other animal matter containing animal parasites.
   a. Such as cannot be transferred to man at all, or at least not in the stage of development concerned: *Distomum hepaticum* and *lanceolatum*, vesicles of Echinococcus or Coenurus, Miescher's tubes or the actinomyces of swine when very numerous, pulmonary worms. *Taenia coenurus*, *Taenia echinococcus*, and pulmonary worms do not develop in man; Distomum only if the larvæ are swallowed, Echinococci only on swallowing the ova.
   b. Calcified specimens of parasites which have died spontaneously, and which would otherwise be dangerous to man, such as Trichinæ.

No objection can be raised against the consumption of

such meat and its sale at a low price, and with due declaration it cannot be objected to. Meat infested with parasites to a great extent is to be destroyed as exceedingly disgusting. Above all things care must be taken that dogs do not devour the diseased organs with Coenurus cysts or Echinococci, thus infecting themselves and giving opportunity to spread parasitic infection.

§ 255. III. In the following diseases the flesh must be pronounced exceedingly loathsome and perilous to public health, although it may be consumed by men without injury, if the beasts are slaughtered at the very onset of the disease:

Cattle-plague,	Charbon symptomatique,
Pulmonary disease,	Sheep-pox,
Bacillary erysipelatous fever,	Swine-plague.

Although the meat of class III., whether raw or cooked, has never yet given rise to disease in man—mankind not being susceptible to the diseases in question—yet its sale, and, as a rule, its consumption, should be most strictly prohibited, since such meat, as long as it is raw, may spread diseases among animals and seriously threaten national prosperity. On the other hand, in districts gravely attacked by an epizoötic, the use of meat from animals certified by the veterinary surgeon as having been slaughtered at the commencement of the disease, may be safely allowed to men, though, of course, in a cooked state, and with a declaration of its nature. In fact, it has been consumed without injury on a large scale in epizoötics, *e.g.*, cattle-plague. Such meat will always, however, be considered disgusting, at least to persons not accustomed to it.

Thorough investigations have shown that whilst the bacilli of erysipelas die at 52°, boiling, pickling, roasting, and smoking destroy the bacilli very slowly and imperfectly, and that consequently such meat, even when cooked, involves a certain danger for the stocks of swine. (Petri, *Arbeiten aus dem Kaiserl. Gesundheits Amt.*, vi.)

Persons in Austria have been taken ill after consuming the flesh of erysipelatous swine, which had not been sufficiently cooked. This can scarcely have been in cases of bacillary erysipelas, which, according to Bollinger and Schottelius, does not render the flesh injurious. The flesh of animals affected with swine-disease, as long as it was regarded simply as pneumonia, was admitted for food without hesitation, and has never occasioned any injury. The meat of animals suffering from charbon symptomatique is very commonly consumed in Upper Bavaria without penalties; in Baden it is prohibited. Lemke observed severe diarrhœa in young dogs which had been fed upon such meat.

If beasts are slaughtered only in the later stages of the disease, the flesh is generally so changed, and is consequently so disgusting, that its prompt destruction becomes obligatory. It is best to prohibit its use as soon as distinct pathological changes are observed on slaughtering. In the later stages of the disease there often occurs a mixed infection with septic microbia, as in sheep-pox.

§ 256. IV. We must pronounce unconditionally injurious, or suspicious of unwholesomeness, the meat of:

1. All beasts which have perished from disease, or have been slaughtered compulsorily on account of disease, especially of a febrile character, except on production of a veterinary certificate that it is edible, with a statement of the reasons. Here must be included all meat saturated with blood, with œdematous liquids, or of a yellow or other anomalous colour, of abnormal taste and smell, unless it is referred by veterinary certificate to one of the former categories.

If the presence of diseases is shown which have no influence upon the general condition, the use as food of a beast slaughtered under such circumstances may be permitted, *e.g.*, in tympanitis from fodder of an excessive quantity or unsuitable kind, extraneous bodies in the respiratory organs, incomplete parturition, accidents of all kinds. The veterinary surgeon has to decide whether such meat belongs to category I. or II.

In Saxony the flesh of a beast which has been slaughtered more than twelve hours after an injury may only be sold on production of a veterinary certificate.

Hygiene cannot pronounce the flesh of animals which have died of diseases as injurious *per se*, especially as death from apoplexy (effusion of blood on the brain) must be considered equivalent to death from a bullet-wound in the brain. But, in the first place, a beast which has died a natural death is not completely bled; the meat is consequently, in our ideas, rendered poor in appearance, if not unappetising, and passes quickly into putrefaction. Secondly, the public has such an instinctive aversion to the flesh of beasts which have perished that it is well to uphold on principle the prohibition of the consumption of such meat, unless the official veterinary surgeon places it in category II. Concerning certain infectious diseases of beasts to which man is not liable see §§ 254 and 255.

The following diseases of the lower animals are particularly dangerous to man:—

A. Animals affected with glanders, tuberculosis, splenic fever, malignant œdema, septic processes, foot and mouth disease, possibly also *Actinomyces bovis*, tetanus, and rabies, are dangerous in cutting up and dressing the meat, especially in presence of small wounds in the fingers.

The bacilli of glanders seem able to penetrate through the healthy mucous membrane, whence contact with them is in the highest degree dangerous to man. Cases of infection with tuberculosis by an injury received during dissections and slaughterings are known in great numbers. On splenic fever see the following page.

Foot and mouth disease is sometimes communicated to man by the secretion of the vesicles, to the attendant or to the slaughter-man, and leads to a disease quite analogous to that of cattle.

In the dissection of rabid animals infection has only once been found to be communicated to man. The muscular flesh and the blood do not contain the poison of rabies. No case of rabies has been recorded from eating the flesh of rabid cattle, which has been often observed. In any case, no objection can be raised against slaughtering and consuming cattle which have been killed after a suspected bite, but before the actual outbreak of the disease.

B. Meat is dangerous if consumed in the following cases:—

a. Dangerous only if consumed in a raw condition, the unwholesomeness being destroyed by cooking: cysticerci and trichinæ, tuberculosis, glanders, actinomycosis, foot and mouth disease.

From the larval states of *T. solium* and *T. mediocannellata* tapeworms are developed in the human intestines. (For their tenacity of life see § 243.)

Notwithstanding the official inspection, numerous persons still die yearly of trichinosis. In 1883, at Deesdorf and Nienhagen, 503 persons were infected by the flesh of a single trichinous pig, and 66 of the cases proved fatal. In 1865, at Hedersleben, 337 persons were attacked, and the deaths were 101. (For their tenacity of life see § 241.)

The bacilli of tuberculosis in meat and milk resist strong attacks fairly well: a temperature of 60° for twenty minutes and one of 71° for ten minutes do not injure them, as little as does desiccation at 30°. They also resist for a long time putrefaction, salting, and alcohol (Galtier, *Comptes Rendus*, 104 and 105). Dried bacilli remain for months capable of life.

Whilst certain proofs are at hand that tuberculosis may be caused by eating the bacilli of tubercle, and whilst no one doubts that the consumption of raw animal organs interspersed with the nodules of pearly disease is highly dangerous, the question, in spite of many investigations, is not quite clearly decided as to the dangerousness of the flesh of tuberculous animals if the few macroscopic tubercle-nodules are not present in the actual pieces of muscle consumed.

Whilst Johne concluded from the dietetic experiments recorded in literature that 47·7 per cent. of the animals experimented upon were infected by the ingestion of the raw flesh of tuberculous animals, and 35·5 per cent. by the use of such meat which had been boiled for ten to fifteen minutes, Bollinger (*Deutsche Zeitschrift f. Thiermediz.*, vol. xiv. 1888) advocates the harmlessness of the flesh of highly tuberculous animals if the tubercular nodes (a great rarity) have not been actually developed in the muscles. Kastner, with Bollinger, has injected into twelve guinea-pigs the expressed juice from the muscles of highly tuberculous cattle which had been slaughtered; and notwithstanding the selection of this most certain method of infection, he did not obtain any positive results (*Münch. Med. Wochenschrift*, 1889). In opposition to Kastner, Forster found the flesh of animals affected with "pearl-disease" often infectious. Steinheil (*Münch. Med. Wochenschrift*, 1889), who with Bollinger injected eighteen rabbits with the juice of Iliopsoas from men dead of tuberculosis, obtained entirely positive results. Experiments with the muscular juice of animals which have died of tuberculosis are still wanting. The confiscation of the flesh of every animal which displays tuberculous changes, as done in Berlin, and as resolved on by a great majority of votes at the first International Congress on tuberculosis at Paris, seems to me not well grounded. The view taken by Bollinger seems to be the correct opinion for practice; animals with localised tuberculosis are referred to category I. *b* (§ 254); those with generalised tuberculosis may at most be utilised for glue and stearine, unless means are found of thoroughly boiling the entire flesh before sale, as has recently been attempted in several abbatoirs (*e.g.*, in Berlin). As long as the meat is not loathsome, this is decidedly the best way for its utilisation.

Pickling and smoking, as practised for the kitchen, do not, according to the experiments of I. Forster with meat containing the nodules

of "pearly disease," appreciably diminish the infectious character of the bacilli of tubercle.

Attacks of glanders in animals (especially in the Felidæ), in consequence of infective food, have been observed in zoological gardens. No infection has hitherto been demonstrated in man from the use of such meat (Decroix even ate the raw flesh without injury), but the possibility of infection is beyond doubt (*e.g.*, by raw sausages made of horse-flesh).

Diseases in man which can be with certainty referred to the use of organs containing actinomyces as food are hitherto not known; but the possibility of infection must be unconditionally admitted, especially for the actinomyces of oxen. Meat containing such parasites is always disgusting.

In Berlin pork interspersed with actinomyces is destroyed, but Johne considers this unnecessary.

Foot-and-mouth disease has not hitherto been certainly transferred to man by the use of meat, and when cooked the meat is harmless; but the raw meat should be handled carefully, as man enjoys no immunity against the disease. (See Milk.)

β. Meat is dangerous, both in a raw and a cooked state, in cases of: splenic fever, malignant œdema, sepsis, and chicken-cholera.

An incomplete salting for fourteen days does not suffice to kill the bacilli in a ham from a pig affected with splenic fever. Salting for 1½ months is effective (Peuch, *Comptes Rendus*, ex. p. 285, 1887). Desiccated bacilli free from spores, according to Koch, are capable of survival for at most five weeks.

Well-boiled splenic fever flesh is seldom dangerous, as the sporeless bacilli perish at 60°, and no great quantities of ptomaines are contained in the meat. Meat in the raw state is, on the contrary, very dangerous. If the meat is kept in a warm place (20° to 25°), the bacillus develops spores on the surface of the meat (Schmidt-Mühlheim, *Centralblatt f. Bacteriologie*, vi.), which for a short time (from one to five minutes) resist even the temperature of ebullition, and can bear 80° for half an hour. Twelve cases of illness occurred in Germany in 1887 from the consumption of splenic fever meat, as against seventy-eight from flaying the carcases. Bollinger (*Zoonosen*) reports several cases where the butchers were taken ill, though the consumers remained in health. The symptoms of infection in man proceeding from the bowels are: sudden severe sickness, with languor, nervous symptoms, vomiting, diarrhœa, cyanosis, collapse. Cuticular carbuncles and the œdema of splenic fever may also occur in infection by way of the bowels. I am not able to find any certain statements concerning malignant œdema. The consumption of poultry suffering from chicken-cholera has occasioned sickness in man.

Of by far the greatest importance in practice is the poisonous character of the flesh of cattle suffering from septic pyæmic processes. The flesh is generally pernicious, whether boiled or raw. Boiling indeed often slightly diminishes its malignity, but the broth has often been found intensely poisonous. The meat, therefore, along with pathogenic microbia, contains the poisonous products of their metabolism.

It is beyond doubt that various kinds of septic bacteria may have occasionally come into action. Hitherto only a few cases of meat-poisoning have undergone a careful bacteriological study. For the results see § 249. The symptoms of the cases studied by Gaertner and referred to *Bac. enteritidis* were: violent catarrh of the stomach and bowels (sometimes with blood in the evacuations), with deep prostration, weakness of the heart, with rapid pulse, fever, pains in the limbs. On dissection, there appears strong injection of the small intestine, which is filled very full; smaller and larger hæmorrhages in the most varied organs, especially underneath the mucous membrane; the spleen not enlarged.

The symptoms of an acute septic enteritis as here described predominate in the majority of the cases of meat-poisoning which have been reported, though individual cases show a number of variations. Sometimes there occur nervous symptoms (paralysis of the muscles of the eyes, troubles of the pupils, difficulties of deglutition, &c.). In Gaertner's epidemic, convalescence was accompanied with desquamation of the skin of the fingers; in other cases nettle-rash has been observed.

A second group of diseases after the use of meat takes the aspect of cholera (see, *e.g.*, *Hygien. Rundschau*, i. 196).

A third group, lastly, of meat-poisoning cases assumes the deceptive clinical aspect of *Typhus abdominalis;* the incubation is more prolonged (generally from four to nine days). On dissection, the results seem to support the diagnosis as *Typhus abdominalis* (tumour of the spleen, ulcerated intestine). Here must be placed the two most extensive "flesh epidemics" hitherto known (see *Die Fleischvergiftungen von*

Andelfingen [1839, 391 cases, 10 deaths] and *Kloten* [1878, 657 cases, 6 deaths] by Dr. J. J. Suter, *Hygienische Tagesfragen*, vi., Munich, 1889). In any case, notwithstanding all approximations, there is here no question of *Typhus abdominalis*, against which all the lower animals possess an immunity, but of a septic micro-organism of pathogenic attributes. In the Kloten epidemic the cause was traced with certainty to two young calves which had been attacked with septic disease. Many secondary cases in the families of the patients were especially noteworthy.

2. The flesh of all animals which have perished with the symptoms of an acute poisoning by organic compounds. Strong views were formerly taken on the dangerous character of the flesh, not only of poisoned animals, but of such as had been treated with organic medicines. In fact, literature contains a number of cases of this kind, though certainly lacking in part full critical observations.

Thus there have been observed beef rendered poisonous by atropine; poisonous flesh of lambs which had been experimentally killed with nux vomica; in Australia, poisonous flesh of sheep which had perished from browsing poisonous cucurbitaceæ (*Jahresbericht f. Pharmak.*, 1871); poisonous fishes poisoned with *Cocculus indicus;* poisonous snails which had fed upon the box-tree. A large dose of powder of hellebore, which had been administered to a cow medically by a quack, rendered its flesh poisonous. Recent experiments by Fröhner and Knudsen completely demonstrated the harmlessness, both to men and dogs, of the flesh of sheep which had been fatally poisoned with eserine and strychnine, pilocarpine and veratrine (*Zeitschrift f. Fleisch u. Milchhygiene*, vol. i.), whence they infer that it is impossible to render flesh poisonous by the medical treatment of the animals. This naturally holds good only for the muscles, liver, kidneys, and heart. On the contrary, the stomach and the intestinal canal may easily become poisonous.

An animal may easily be rendered sick by metallic poisons (especially lead and arsenic), but its flesh is not thus rendered poisonous. Lead has been found in all experi-

mental poisoning cases only in traces in the tissues. Sonnenschein found in 1 *kilo* of the flesh of a cow, which, in the course of six months had taken medicinally 506 *grm.* of arsenic, only 0·4 *mg.* After the ingestion of tartar emetic Harms showed the harmlessness of the flesh. As various poisons are found in large quantities, the stomach, along with the entire intestinal canal, should be removed by way of precaution. Concerning arsenic, and especially concerning copper and zinc, there exist, in fact, statements as to their presence in the liver in a relatively high proportion. That meat may become poisonous by the accidental introduction of lead (use of leaden chopping block, &c.) is a matter of course.[1]

II. Meat in Incipient Decomposition.

§ 257. 1. The flesh of healthy, and still more of diseased animals, when beginning to pass into putrid decomposition, may become exceedingly dangerous. A slightly putrid odour does not, according to Gerlach, indicate injurious decomposition if the meat is from healthy animals, "but if it really stinks, and has become inferior-looking, brittle, and smeary, if the loose connective tissue between the muscles, and especially between the muscular fasciculi, has taken a greenish colour or is quite decayed, whereby the meat on a cut surface appears porous," it must be rejected as injurious. Long before this point it is naturally disgusting: *Haut goût.* (§ 239.)

It is said that negroes often reject as exceedingly disgusting raw fresh meat and eggs, whilst they consume readily, and even by preference, the semi-putrid residues of the meals of beasts of prey, stale and half-hatched eggs, if only they are cooked.

A multitude of cases have been published in which meat,

[1] The author does not raise the question whether the flesh of poultry, rabbits, &c., may become poisonous by feeding upon plants or insects which are perfectly harmless to them, though dangerous to other animals. French army surgeons in Algeria report that the frogs there prey largely on cantharides, and that the soldiers by eating such frogs are sometimes attacked with cystitis.—*Editor.*

fish, patés, lobsters, &c., were consumed when fresh and proved to be perfectly wholesome, whilst the very same viands, if eaten one day or a few days later, occasioned the most severe sickness. (See, *e.g.*, Schmidt-Mülheim in the *Zeit. f. Fleischbeschau und Fleischproduction*, 1887, H. 3, 4, 5.)

Here we unquestionably have to do with the formation of ptomaines by means of bacteria which in any manner (from the air or from impure surroundings) find their way into food. Properties which particularly strike the senses are mostly absent in such "spoiled" foods. Hence, in deciding upon doubtful cases, every slight indication of spoiling, such as a somewhat modified smell, taste, colour, appearance, consistence, &c., must once for all be characterised as exceedingly suspicious, and possibly dangerous. The symptoms observed after the consumption of such spoiled foods have the greatest similarity to those produced by the ingestion of the flesh of animals suffering from septic disease. The types of disease in individual cases vary greatly, according to the ptomaines which have been generated.

Recently A. Pfeiffer and Schmidt-Mülheim detected between the layers of a "salmon-ham" (*i.e.*, salted salmon), which, notwithstanding the faultless appearance of the meat, had occasioned injury to health, a curved bacillus, which produced slimy masses, and was easily cultivated on artificial media.

There is especial danger in the consumption of the flesh of morbid (especially septically morbid) animals when it has been kept for a long time. The formation of ptomaines, which had begun during life, evidently increases considerably afterwards. Such meat decomposes with exceptional rapidity; the more rapidly any meat decays, the more dangerous it usually becomes.

2. *Mouldy* meat is loathsome and suspicious.

3. It is not easy to decide once for all concerning "luminous meat." *Bacterium phosphorescens* (see § 239), which in our climates is the main cause of luminosity, forms, if cultivated in broth, no poisons. (See K. B. Lehmann and Tollhausen, *Centralblatt f. Bacteriologie*, v.) As we learned, luminous meat is roasted in masses, and is eaten without

injury. The development of the luminous bacillus does not therefore *per se* involve any injury to health; it is not even an indication of abnormally long preservation, or of too high a temperature of the larder, &c. Still such meat is decidedly disgusting, and the possibility that, along with the harmless luminous bacilli, injurious microbia may have been developed, is never excluded. In decided putridity the luminosity diminishes, or is quite extinguished.

APPENDIX I.—SOME NOTES ON AQUATIC ANIMALS.

§ 258. Whilst in our climate there occurs no mammal or bird the flesh of which is *per se* poisonous, some otherwise much admired aquatic animals are at times poisonous. Especially in the perch (*Perca fluviatilis*), sometimes also in the pike and the burbot (*Gadus lota*), the roe and the ovaries at the time of spawning contain poisons which act like cholera, though the males are usually harmless. Mussels are sometimes altogether very poisonous, especially the liver and the ovaries. In mussels it is proved that their residence in polluted waters is the cause of the poison, which, according to Schmidtmann, disappears in pure sea-water; a similar cause is conceivable in many cases for fish.

Poisonous perches have no peculiar external feature; poisonous mussels have generally thin shells, not of a dark blue, but brownish; the flesh and the alcoholic extract are of an orange-yellow; the smell often resembles that of wadding. Mussels of this appearance are not admissible for consumption. An exact decision as to their poisonous nature can be obtained only by an experiment on rabbits (subcutaneous injection of a concentrated decoction of mussels). Brieger has prepared several ptomaines from poisonous mussels.

Similar observations have been made concerning poisonous oysters, shrimps, crabs, &c.[1]

[1] The mackerel (*Scomber scombrus*) is accused of being occasionally poisonous. The evidence is scarcely satisfactory, and the reported cases may be traceable to incipient decomposition, which in this fish sets in rapidly.

For distinguishing fresh from stale fishes, the following characteristics will serve :—

	Gills.	Flesh.	Eyes.	Specific Gravity.
Fresh Fish.	Bright red. Smell on pulling the gills open is fresh.	Firm, adheres to the bones.	Prominent, firm; cornea transparent.	Sink in water.
Stale Fish.	Pale yellowish or greyish red. Sometimes fraudulently coloured. Smell unpleasant.	Loose, comes off easily from the bones. Impression of the fingers are permanent.	Sunken, their surroundings reddened; cornea dull.	Float in water.

Stale, diseased, or dead aquatic animals (fish, crabs, mussels, &c.) are to be regarded as loathsome, and under certain circumstances very dangerous to health. Elsner regards crabs which have died of the saprolegnia plague as dangerous to health. Crabs boiled after a natural death do not display rolled-up tails. Concerning fishes poisoned with *Cocculus indicus* see § 256.

APPENDIX II.—EGGS (EGGS OF THE COMMON FOWL).

§ 259. It is well known that a fresh egg is translucent if we hold it in the hand, closed in the shape of a tube, and look through it up at the bright sky; putrescent or incubated eggs are less pervious to light. Fresh eggs sink at once in a solution of common salt containing from 5 to 10 per cent.; stale eggs, which have lost weight by the evaporation of water and the absorption of air, float more or less perfectly. The albumen of eggs which have been kept in milk of lime or otherwise preserved for a long time loses the property of being beaten up to froth.

As long as an egg does not betray itself as bad by smell and taste, it can scarcely ever be unwholesome. Incubated eggs are disgusting, but not hurtful, unless putrescent. Preserved egg-albumen may become very dangerous by the formation of ptomaines (Glasmacher, *Berlin. Klin. Wochenschrift*, 1886).

BIBLIOGRAPHY.

See end of following section.

SECTION VII.

PREPARATIONS OF MEAT AND PRESERVED MEATS.

1. Sausage.

§ 260. In preparing sausage, chopped meat or the blood and internal organs (liver, lungs, heart) of various slaughtered beasts, along with salt and other condiments, are filled into the cleansed bowels (more rarely, the bladder and the stomach) of oxen and swine, and recently into cases of parchment.

The exact composition of sausages varies enormously in different districts, but the following types recur constantly:—

1. *Meat sausage.*—Pork, veal, beef, and fat. Smoked, boiled, or roasted.

   Here belong "cervelat" sausage, the sausages of Lyon, Ratisbon, and Gotha, ham sausage, garlic sausage, Frankfurt roasting sausage, &c.
2. *Black pudding.*—Chiefly swine's blood and pork fat. If much cartilage or bacon is added, the result is rind sausage.
3. *Liver sausage.*[1]—Liver, kidney, omentum are finely chopped, along with sinews and cartilage. It is boiled or roasted like the former.
4. *White sausage.*—Pork and veal with onions, white bread, and milk. Boiled.

   As additions, pepper and salt are constantly used, and in endless variety: pimento, saltpetre, coriander, bay, cloves, onions, garlic, chives (*Allium schoenoprasum*), pistachios, basil, marjoram, truffles, sardines, &c.

The preservation, according as the sausages have to be kept for a longer or shorter time, is effected in various manners.

[1] Liver cheese is a mixture of liver and blood with meal and bread-crumbs. It is not filled in skins, but sold as a cheap paste. The decision on this cheap product (very popular in Munich) does not come under this heading.

1. Sausages for prompt consumption are :
   a. Boiled or kept at 70° for at least twenty minutes (scalded).
   b. Smoked.
      a. Kept in smoke for sixty to ninety minutes. In order to remove the wrinkles they are afterwards scalded.
      β. Subjected to the "rapid smoking process." (See 2*b*.)
2. Sausages for longer preservation are always poorer in water, and are more carefully smoked :
   a. They are wrapped in paper or linen (to prevent the deposition of soot) and suspended in smoke for a long time ; or,
   b. They are repeatedly brushed over at short intervals with a mixture of 1 part pyroligneous acid (wood vinegar) to 3 parts of water. The acid is allowed to soak into the sausage in a warm place, and is then brushed over again. The process is complete in one day. On the large scale this method is almost exclusively applied.

It is manifest that in the manufacture of sausages a large quantity of inferior meat is used, which as such would not find ready sale,[1] *e.g.*, the abdominal muscles, the neck, &c. To this no objection can be raised, though other circumstances render a strict hygienic control necessary. It is most important to ascertain the proportion of water, starch, foreign colouring matters, the use of diseased or spoiled meat, bad skins, and the freshness of the sausage.

A. *EXAMINATION OF SAUSAGE.*

I. Examination of the Chemical Constituents.

§ 261. 1. *Proportion of water.*—About 20 *gms.* are comminuted, spread out, dried at 100° for about twenty-four hours, and weighed.

2. *Fat and albumenoids,* if necessary, according to § 211.

3. *Starch.*—Latterly it has become customary to add to the sausage mass starch, from 2 to 5 per cent. (up to 20 !).

Detection.—The cut surface of such sausages, if touched

[1] It must be pronounced disgusting when the embryos of calves found on slaughtering cows are chopped up. The common practice of using the blood of beasts caught during slaughtering is very dangerous, as they may afterwards be condemned on inspection.

[Blood should never be used for human food ; its proper employment is in making manures.—*Editor.*]

with an iodised solution of potassium iodide, turns blue. In uncooked sausages we can detect with the microscope blackish-blue clots; in cooked samples there appears a more diffused blue colour, as the starch is converted into paste. The qualitative examination is always certain if the result is strong; every sausage contains, indeed, small quantities of starch in the spices (pepper), but these are never sufficient to occasion a diffused macroscopic blue stain over the cut surfaces on the application of iodine. The quantitative determination is effected by converting the starch into sugar (§ 221).

4. *Colouring-matters.*—Portions are extracted with ethylic or amylic alcohol; if anything dissolves with a red colour, artificial colouring-matters are present. Colours are also used which cannot be thus detected, *e.g.*, cochineal, soluble in ammonia.

5. *Saltpetre.*—To give the meat a fine red colour, saltpetre is universally employed, but it has no preservative action.

Detection.—The qualitative detection is effected in an aqueous solution as directed in § 181. Rabuteau recommends (*Gaz. Méd. de Paris*, 1874) to prepare an extract in hot water free from fat, to precipitate it for quantitative determination with lead acetate, to remove the lead from the filtrate by means of soda, and to filter again. If the filtrate is now evaporated to dryness and extracted with absolute alcohol, the nitrates are left so pure that they may be dissolved in water and determined as in § 181. Small quantities of nitric acid may be derived from the water used. According to Menges (Serafini, *Archiv f. Hygiene*, xiii.), there are added to sausages which have to be kept for a long time from 2 to 4 *grm.* per kilo. of meat; to such as are to be promptly consumed, from ½ to 1 *grm.* Serafini found 0·05 to 0·55 per cent. About half the sausages contained no saltpetre at all.

Saltpetre is a decided poison. 5 *grm.* can occasion serious illness, and 8 *grm.*, though mostly from 8 to 15 *grm.*, have proved fatal. The literature at my disposal contains nothing on saltpetre poisoning, acute or chronic, from the consumption of meat.

Serafini has recently collected a large number of statements from the literature of the toxicology of saltpetre (*Archiv f. Hygiene*, xiii.), from which I borrow the result that there has been observed a very variable degree of sensitiveness to poisoning with saltpetre. On one occasion 1 *grm.* produced nausea, vomiting, and long persistent want of appetite (Kemmerich). The nitrates pass partly in the body into nitrites, which are much more poisonous.

The question as to the poisonous character of saltpetre seems to require a special experimental investigation.

6. *Organic poisons.*—Ptomaines. See § 79.

This investigation may be very readily found needful, but it can be undertaken only by a chemical specialist. (See Ehrenberg, *Zeit. f. physiologische Chemie*, 1887, vol. xi., and Brieger, *Zeit. f. Fleischbeschau*, 1888, No. 9.) "Sausage poison" is no unitary or constant substance.

II. Examination of the Flesh of Diseased Beasts.

§ 262. *Animal parasites.*—Concerning trichinæ see § 241.

Cysticerci are easily found by the following method (*Schmidt-Mülheim*):—In a conical glass there are placed along with about 10 *grm.* of sausage 100 *cc.* hydrochloric acid at ½ per cent., and 5 *cc.* of pepsine-glycerine (obtained by allowing the mucous membrane of the purified stomach of a dog or a pig to soak with glycerine for eight days, and then digesting it from four to six hours at 40° with frequent stirring). Whilst the flesh and the cysticercus vesicles are dissolved and the fat floats on the surface, the head-processes of the cysticerci are scarcely attacked by the pepsine, and sink to the bottom as masses resembling grains of rice, showing a distinct transverse sulcation. The head may be separated by means of preparing needles. In dilute glycerine under a magnifying power of about 100 diameters the suction pits may be distinguished, and, in case of *Cysticercus cellulosæ*, the hooks. It is more difficult to find in the sediment the portions of membrane with the heads of Echinococcus armed with small hooks.

The smell, the taste, the consistence, and the colour are to be carefully examined.

Bacteriological examinations (see § 239) show very high numbers of microbia. Deetjen (*Dissertation*, Würzburg, 1890) detected in 1 *grm.* of fresh "Lyon sausage," according to the time of boiling:

Unboiled, quite fresh	1,894,000	schizomycetes
Kept unboiled for four days . .	6,654,000	„
Boiled by the author for quarter of an hour	61,000	„
Boiled by the author for half an hour .	9,000	„

Obtained fresh from the maker (ready for use): in winter, from 324,000 to 448,000; in summer (better boiled), from 14,000 to 37,000.

Sporiferous bacilli, chiefly of species which bordered on *Bac. mesentericus vulgatus*. They must have been present partly as bacilli, but partly in the state of spores. In "cervelat" sausage, made at Gotha, and faultless in appearance, microbia were found up to 5½ millions, doubtless on account of the long preservation.

Much more important than such enumerations is the search for pathogenic species which are little affected by the ordinary preparation of sausages. See the statements of Gaffky and Paak, § 249, 10. Compare also the notices in § 266. The researches of Serafini at Munich (*Archiv f. Hygiene*, xiii.), like our own, showed chiefly a spore-bearing microbe, which he determined as *Bacillus mesentericus vulgatus*, and which, according to him, is derived from the sausage-skins employed.

B. *CRITICAL EXAMINATION OF SAUSAGE.*

§ 263. 1. *Proportion of Moisture.*—Very watery sausages of low value are often met with in trade (with or without starch).

Trillich found at Munich in ordinary meat sausages from 63 to 79 per cent. of water. A degree of moisture of more than 70 per cent. characterises these sausages as inferior. König regards 56·6 per cent. as the maximum, and from 40 to 50 per cent. as the normal moisture of good sausages.

Of course sausages rich in water are more liable to decomposition than others, and are on this account open to objec-

tion. It seems that for cheap sausages the determination of moisture is the most important point.

2. *The Addition of Meal* (crumbs of white bread must be considered similar).—According to the assertion of the makers, the addition of starch is to

1. Render the sausage-mass more coherent.
2. Improve the appearance.

The intention in adding starch is at the same time:

1. To substitute cheap starch for a part of the more expensive meat.
2. To produce a more hygroscopic and at the same time more showy sausage.
3. To prepare a coherent sausage from inferior, sparingly coherent meat.
4. To protect the sausage against loss of weight on keeping. Sausage free from starch loses from 10 to 15 per cent. in three or four days; such as contain starch, it is said, much less.

Points 1, 3, and 4 depend upon correct though covetous considerations; but as regards point 2 we must remark:

It is certain that a sausage, if boiled for a time for consumption, retains decidedly more water (from 20 to 25 per cent. more than raw) if from 3 to 5 per cent. of starch has been added, as Naumann and Long observed (*Chem. Zeitung*, ix. 97). Of course such a boiled sausage is bulkier and heavier. But if the sausage, as it is customary in many places in South Germany (especially Munich), is not really boiled, but merely laid in water at 70° for twenty or twenty-five minutes, the proportion of starch (from 1 to 10 per cent.) is without influence on the power of retaining water. Sausages made experimentally with very watery meat (up to 79 per cent.), and free from starch, lost only from ½ to 3½ per cent. of their water, whilst others prepared with an addition of starch behaved the same. (Trillich, Sixth Meeting of the Association of Bavarian Chemists, 1887.)

The superior courts have predominantly pronounced against sanctioning an addition of meal:

1. Because it is unnecessary if good materials are employed

(sausages of the most celebrated makes are always found free from starch).

2. Because it aims at a deception of the public, at least by substitution of meal for meat, and sometimes even of water for meat.

See Bollinger, *Zeit. f. Thiermedizin*, iii. 1887.

Except the decrease of the nutritive value, it does not appear that any hygienic grounds tell against this use of meal, but that is sufficient to call for the opposition of physicians. It has not been shown that paste sausages spoil more rapidly.

3. *Colouring-matters.*—Even the employment of harmless colouring-matters for dyeing sausage mass is objectionable. If the pigment is non-poisonous, its use probably shows a desire to make an inferior product appear better. An inferior article will not rarely prove at the same time unwholesome. Reichhardt (*Archiv f. Pharmacie*, 1873) describes the illness of an entire family from the consumption of coloured though non-arsenical sausages.

4. *Use of the Flesh of Diseased Animals.*—All circumstances which render fresh meat unwholesome or more or less disgusting exclude it on principle from use in sausage-making. In view of the difficult control of sausages, hygiene must demand that only meat of the categories I.*a* and *b* shall be employed.

Fresh sausages have often proved poisonous, especially if the flesh of septic beasts has been used, chiefly in raw sausages or in such as have been imperfectly boiled or roasted. The flesh of healthy horses is not objectionable for sausage meat, but its use must be stated to the purchaser (§ 238).

Similarly, the bowels of diseased beasts must be rejected as utterly loathsome and dangerous—such, *e.g.*, as contain tubercular or septic ulcerations.

§ 264. 6. *Spoiled Sausages.*—The slightest suspicion of corruption, the slightest change in the smell, taste, colour and consistence of a sausage exclude it from consumption. The fearful dangers of sausage-poisoning must determine us

to take up the strictest point of view. Poisonous sausages are smeary, pasty, slightly acid, and have readily a putrid odour and taste. The colour is mostly changed from red to grey. Cases, however, have been recorded in which sausages of alleged faultless properties have proved poisonous. As yet, certain indications for poisonous sausages have been wanting.

The changes begin in the interior of the sausage, where the preservative action of the smoke has penetrated least; thick sausages which have been kept long are especially dangerous. Kussmaul described a case where the flesh of a diseased cow was consumed without injury, whilst a "Schwartenmagen"[1] prepared from portions of the cow very quickly occasioned the most violent poisoning (*Archiv f. Klin. Med.*, iv.).

The symptoms of sausage-poisoning vary considerably in individual cases, but the following are rarely absent: gastro-enteritic phenomena, intense debility, dryness of the œsophagus, paralysis of different muscles, especially of the eye, and difficulty of deglutition. Disturbances of consciousness have likewise often been observed. For the bibliography of the subject see Spät in *Friedreich's Blätter*, 1889, p. 469.

2. Tinned Meat and other Tinned Preparations of Animal Origin.

§ 265. The contents of the tins are sterilised by heat. If they are of a fresh odour and of an unsuspicious taste, their examination must extend principally to:

1. Water, fat, albumen, and common salt, in order to decide upon the nutritive value.
2. Preservative agents: common salt, boric acid, salicylic acid, saltpetre.
3. Metals that have been dissolved off the sides of the tins: lead, tin, zinc, copper. (See §§ 460, 461, and 462.)

[1] Sausage-meat containing much fat and cartilage, and filled into a stomach.

Schützenberger and Boutmy detected in sixteen tins of preserved meats, in which they examined only the layer in contact with the metal in 100 *grm.*: from 5 to 125 *mgrm.* of tin, from 8 to 148 *mgrm.* of lead, and considerable traces of copper. A great portion was probably derived from the solder.

The examination for trichinæ and echinococci is effected without especial difficulty as in sausage. The meat of diseased animals cannot in general be detected. Of course every indication of an escape of blood into the muscles, or of other pathological symptoms, must be regarded as disgusting and as suspicious in regard to unwholesomeness. If the contents of the tins are spoiled, if they have a suspicious smell (especially on cooking) or taste, they must be regarded as extremely dangerous. The contents of tins, which were originally sound, if left standing open in the air may become poisonous from the formation of ptomaines. Thus, according to Camus (*Rev. d'Hygiène*, 1877), the first half of the contents of a tin of lobsters was harmless, but the rest a few days afterwards was very poisonous.

The presence of bacteria in tinned meat, as it has been sometimes found (for the bibliography see Serafini), by no means proves it to be spoiled. The resistent spores of bacilli may survive the process of sterilisation without endangering the product in the tin, at least at a cool temperature. Of pathogenic bacteria the spores of splenic fever have at most once remained alive.

All that has been said applies to ordinary salt meat, in which it must be remembered that common salt (up to 5 per cent.) penetrates into the meat by diffusion, whilst some albumen and considerable quantities of extractive matter and of the salts of the meat are dissolved out.

3. Salt Meat, Dried and Smoked Meats, Hams.

§ 266. The meat used for such treatment must strictly correspond to the general requirements for meat to be used as food. Smoking and drying, salting and pickling, attack the animal and vegetable parasites in very different degrees.

Trichinæ (§ 241) and ecchinococci (§ 243) are attacked much more readily than bacteria, among which only bacilli of splenic fever, free from spores, show great sensitiveness. The most necessary details for the several bacteria are given in §§ 71 and 81.

Compare the more extensive works of Freitag and Forster (*Archiv f. Hygiene*, xi.) and Beu (*Centralblatt f. Bakteriologie*, viii. 513).

Ptomaine-poisonings by decayed hams have been observed in considerable numbers.

Dried and pulverised beef, in consequence of slight decomposition of the fat, readily assumes a more or less unpleasant odour, which (along with other causes) has hitherto frustrated all attempts to introduce meat-powder (*carne pura*, &c.) as a popular article of diet.

4. Preserved Fish.

§ 267. For preserved fishes no method of examination has been generally adopted except that by the senses. The strictest judgment of anything in the least suspicious is a duty, since corrupting, and especially badly preserved, fishes have often given rise to severe epidemics. Poisoning cases have especially occurred in the south of Russia from the consumption of sturgeons salted and kept in pits.

Recently Arustamoff (*Centralblatt f. Bakteriologie*, x. 114) has bred from poisonous kinds of sturgeons two mobile short bacilli, microscopically similar to each other, one of which leaves gelatine solid, whilst the other liquefies it. Both proved infectious for rabbits, forming poisonous transformation products in culture, and are regarded by their discoverer as the cause of the poisonous effect of preserved sturgeons. The symptoms are the same as those of meat and sausage poisoning. For the bibliography of the subject see Senkpiehl.

Luminous fishes are to be considered like luminous meat. The red coloration of stock-fish, which has been often observed, and which depends on microbia, does not involve *per se* any poisonous property, but it makes the fish unattractive.

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SECTION VIII.

MILK.[1]

§ 268. Milk is one of our most important articles of diet; but there are few nutrients offered for sale so frequently and to such an extent in a state against which hygiene and national economy must alike protest. This state of affairs is favoured by the indifference of buyers, and is due to ignorance, convenience, or covetousness.

The inspection of milk demands our very special attention for four reasons:

1. Since milk serves as a nutriment at the sensitive age of childhood.
2. Since the common deceptive manipulations reduce very considerably the nutritive value of this distinguished article of diet.
3. As milk is an excellent nutrient medium for very many microbia, whence both poisoning and infections may be readily occasioned by its use.
4. Because even the recent milk of diseased beasts, or of those improperly fed, may occasion poisoning or infection.

A. Examination of Milk.

I. Examination of the Properties which appeal to the Senses.

§ 269. Good cows' milk should be white with a slight yellowish cast, opaque and homogeneous, without flocks or clots, &c. The more opaque a milk the higher is generally its proportion of fat (see, however, § 275). The taste and

[1] All that is said in the following pages refers to cows' milk.

smell are hard to describe, but universally known. Skimmed or watered milk inclines more to a bluish colour; a drop placed on the thumb-nail is more translucent than new milk, and is more inclined to run off. (Nail test.)

By the growth of microphytes, and, it is said, by certain foods, milk often becomes strikingly yellow, red, or blue (see § 297). If allowed to stand in a glass tapering downwards, there are deposited at the bottom particles of dirt derived from cow-dung, and in some cases slimy or tough, colourless or coloured, masses, which must be examined microscopically for pus, blood, epithelium, &c.

Colostrum,[1] *biestings*, the milk secreted a few days before and the first days after calving. It is yellowish, interspersed with flocks and flocculi, insipid and slightly saline in taste. Immediately and for twenty-four hours after the birth the colostrum on ebullition coagulates *in toto* (very much globuline along with increased serum albumen). After some days flakes of albumen separate out on ebullition. The reaction, according to Pfeiffer, is alkaline, according to Fleischmann, generally acid: the proportion of lactose is usually very low.

The examination of milk by taste and smell requires no special direction; both these tests are undertaken with milk which has been gently heated.

II. Microscopic Examination.

§ 270. The fat-globules of milk (from 19 to 17 μ in diameter) were formerly counted up, and their number was used for determining the value of the milk—a troublesome and untrustworthy method. One cubic centimetre contains from 691 to 2291 millions of fat-globules (Tayonaga-Soxhlet). In the colostrum the globules are strikingly unequal in size; along with very small there occur very large globules, and in addition colostrum corpuscules are never wanting (from 15 to 50 μ in diameter) which must be regarded as granu-

[1] To give a notion of the varying composition of colostrum, the following two analyses by Fleischmann are appended:

Immediately after calving: fat, 3·4; total solids, 28·3; caseine, 4·8; albumen, 15·8; lactose, 2·5; ash, 1·8.

One day after calving: fat, 4·0; total solids, 21·3; caseine, 7·3; albumen, 7·5; lactose, 1·5; ash, 1.

The specific gravity of colostrum is from 1·046 to 1·080.

lated epithelium-cells of the mammary-gland in the course of fatty degeneration (Fig. 99).

The cow-dung collected in the tapering glass displays under the microscope vegetable tissue (parenchyma, prosenchyma) and vessels of a yellow or yellowish-green (biliary) colour: starch granules can often be detected in the cells distinctly by the addition of iodine. Starch fraudulently added would also be detected by the microscope (starch-paste,

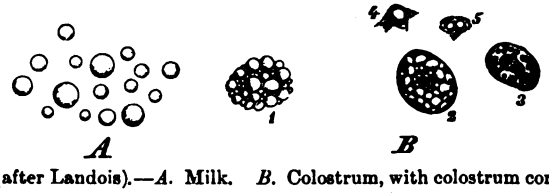

FIG. 99 (after Landois).—*A*. Milk. *B*. Colostrum, with colostrum corpuscules (1, 2, 3) and milk globules, with a margin of albumen.

which is *said* to have occurred, is detected by a blue coloration if the quantity of iodised potassium iodide added is not too small); milk itself takes up a trace of iodine.

Corpuscules of blood and pus are easily detected by the microscope; the spectroscope likewise often does good service in the detection of blood. (For the detection of microbia see § 285.)

III. Qualitative Composition of Milk.

§ 271. 1. *Albumenoids.*—According to Hoppe-Seyler there occur in milk at least two albumenoids:

a. Caseine precipitated from highly diluted milk by a little acetic acid and the introduction of CO_2. According to E. Pfeiffer it may be obtained more conveniently and quite as accurately by adding dilute HCl (2 per cent.) to milk diluted with only five parts of water. (The precipitate includes all the fat which must be removed by treatment with ether.)

b. Serum albumen is precipitated by boiling the filtrate of *a*.

In the filtrate of *b* there are still contained small quantities of albumenoids, which may be precipitated by high concentration and the addition of tannin. The ferment of rennet precipitates especially caseine, whilst albumen remains in solution.

Other methods of precipitation by means of salts, *e.g.*, magnesium sulphate, yield other precipitates variously named. Practically little has been hitherto gained by these divisions.

The practical hygienist for the present will therefore take up the position recently adopted by E. Pfeiffer and Duclaux, and regard all the albumenoids obtained by the precipitation of the albumenoids of milk as mere modifications of caseine.

2. *Fat.*—Butter-fat has a composition differing from that of all other animal and vegetable fats by its proportion of low (volatile) fatty acids. For particulars see Butter.

3. *Sugar.*—In the milk of all mammals (and almost exclusively there) is contained alone milk-sugar (lactose) $C_{12}H_{22}O_{11} + H_2O$, a hard variety of sugar which grates under the teeth and tastes but slightly sweet. For its reduction see § 217, and for its polarising action compare § 30. By the action of the microbia of lactic acid it readily yields fermentation-lactic acid; with yeast it ferments slowly and with difficulty. (See § 92.)

4. Among the constituents of the ash of milk, phosphoric acid, potassium, and calcium are prominent. According to Söldner 25 per cent. of the phosphoric acid in the ash of milk are derived from caseine: all the sulphuric acid comes from the albumenoids. Calcium is, *e.g.*, partly combined with caseine, but a considerable part, according to Söldner, is merely suspended in the milk as tricalcium phosphate.

5. Nitrates, nitrites, and sulphates are absent in pure milk. A little citric acid—according to Soxhlet and Scheibe, from 1·7 to 2 *grm.* per litre—small quantities of urea, cholesterin, lecithin, and hypoxanthin are of no practical importance.

Concerning the products which appear on the decomposition of milk by the influence of different bacteria see § 285.

IV. Quantitative Chemical Examination of Milk.

§ 272. It is especially important to determine:

1. The specific gravity.
2. The total dry matter.
3. The proportion of fat.
4. The acidity.

Of less importance, and rarely required for hygienic and market-police purposes, are:

5. The determination of albumen, milk-sugar, and ash.

All quantitative results are given in percentages by

weight, *i.e.*, *x grm.* substance in 100 *grm.* milk (not in 100 *cc.*).

In every quantitative determination care must be taken:

1. That before each sampling (especially for the market inspection) the milk is most thoroughly mixed by good stirring or shaking. The extreme tendency of the cream to separate out may otherwise lead very readily to false results.

2. The milk must be examined very soon after it is drawn. If this is impossible, it must be set in ice in the meantime, attending to what is said below concerning contraction.

3. In case of exact determinations of small quantities of milk (not exceeding 50 *grm.*), the milk taken must not be measured, but weighed accurately, as it flows more or less completely from the pipette according to its proportion of fat.

As evaporation easily occurs in weighing milk, the following indirect method is taken:—We weigh about from 30 to 50 *cc.* of milk and a glass rod in a beaker covered with a glass plate or in a stoppered weighing-glass, pour out about 10 *cc.* as estimated by the eye, along the glass rod for analysis, and find the remaining weight of the weighing-glass. The difference of the two weights shows the quantity of milk taken.

1. DETERMINATION OF THE SPECIFIC GRAVITY.

§ 273. For this purpose we use a very fine aræometer, especially constructed for milk, and known as a lactodensimeter, preferably such in which the figures representing the third decimal place of the specific gravity are at a distance of 8 to 10 *mm.* from each other, so that the fourth decimal may be read off. The ordinary Quevenne's milk-glass or hydrometer, where the figures are at the distance of 3 *mm.* from each other, is to be used only as a make-shift. All aræometers must be standardised by comparison with the Westphal balance.

The milk-aræometers generally show the specific gravities only from 1·020 to 1·040. Only the figures 20 to 40 are written on the instrument, and we commonly speak (as in the case of urine), instead of a milk as of specific gravity 1·0314, of one of 31·4 degrees. The degrees, therefore, show by how many thousandth parts the milk is heavier than water.

The most necessary precautions in determining the specific gravity of milk are as follows:—

1. The milk must never be weighed immediately after milking, since shortly after milking it rises not inconsiderably (from 0·8 to 1·5 degree). It is not certainly known upon what this depends—perhaps upon a contraction of the milk globules from a subsequent contraction of the butter-fat. In any case the freshly drawn milk should be cooled for about six hours at a temperature of 5° (ice-closet), or at least be placed overnight in a cellar, or in the water of a flowing well, before it is weighed.

Milk obtained in the market has almost always stood long enough after milking to have reached its maximum density before it is brought into the laboratory and submitted to examination, for though milk reaches its greatest contraction more slowly at the temperature of a room than when placed in ice, it is generally completed in twelve to twenty-four hours. In doubtful cases the milk should be weighed again the next day, after prolonged standing in the ice-closet.

2. The milk, before the determination of its specific gravity, should be free from froth. This is effected by pouring it in slowly along the sides of the hydrometer-jar, which should be so wide and high that the instrument may float without touching. The aræometer should be immersed slowly and cautiously, not allowing it to sink far above the correct graduation. When it has come to rest it is plunged at most 1° deeper, and read off after it has adjusted itself. As the milk always ascends a little on the stem of the aræometer, in consequence of adhesion, the true horizontal level of the liquid should always be carefully read off.

3. The specific gravity must never be taken without a simultaneous correct determination of the temperature of the milk, and in the interest of accuracy the milk should always be brought approximately to the temperature of 15° by setting the vessel in cold or hot water; all readings are reduced to this temperature. It is evident that the specific gravity of the milk gives at lower temperatures too high, and at higher temperatures too low, a value. For correction the Table XI. is employed.

2. DETERMINATION OF TOTAL SOLIDS.

§ 274. *According to E. Pfeiffer.*—We place a small platinum capsule in a weighing-glass, pour in from 3 to 4 *grm.* of milk, and weigh again. After exposure to 100° in a drying-closet for eighteen to twenty-four hours, all the water is evaporated, and the capsule is weighed again a few times, until the weight has become constant. As Pfeiffer ascertained by check determinations, this method yields very good results, and the desiccated milk can further be used for the determination of ash (§ 281). The practical milk-chemists, however, persist that a correct determination of dry matter can be effected only[1] by desiccation upon porous material, *e.g.*:—

According to Halenke and Möslinger (modified by Herz), we dry in the drying-closet, in a porcelain capsule of 10 *cm.* in diameter, about 30 *grm.* of sand, previously ignited and extracted with ether, along with a glass rod, and weigh when cold. About 10 *grm.* of milk are poured in, the whole is quickly weighed again, the milk is distributed with the glass rod, and the capsule is placed upon a water-bath which is in brisk ebullition. The water evaporates on frequent stirring; especially towards the end of the process care must be taken for the utmost possible comminution of the clots, which may readily inclose water. Any solid crusts which have been formed may be more easily rendered friable by slight moistening with water. After the water seems to be evaporated the capsule is still left for two hours on the water-bath, which is kept in full ebullition, stirring only at intervals; the capsule is then wiped dry underneath, and allowed to cool in the desiccator; two check determinations should exactly agree with each other, and not a grain of sand must be lost.

According to the Adams method of determining fat, the total dry matter is ascertained simultaneously (§ 277). This method may be particularly recommended.

3. DETERMINATION OF FAT.

A. Approximate Methods.

§ 275. For a long time the attempt was made in practice to make shift with inaccurate instruments for the determination of fat, as their easy application was enticing. But since

[1] Professor J. A. Wanklyn insists, on the contrary, that "the employment of plaster of Paris or sand is to be avoided" ("Milk Analysis," p. 19).

it has been shown that all these methods gave not even approximate but totally inaccurate values, and that under certain circumstances they failed entirely, they are no longer used by any chemist, and the physician will find it preferable not to employ them any longer. (See Vogel.)

As such instruments are still frequently found in the hands of market inspectors, police officials, and of laymen, they must be briefly mentioned.

Above all, those apparatus must be mentioned which depend on the inaccurate assumption that the proportion of fat and the opacity of milk are exactly proportional, and which proceed from the fundamental notion of adding water to a milk until it is so far transparent that a writing or a mark can be distinguished through it. The percentage of fat is then to be concluded from the quantity of water which has to be added to a given volume of milk. Other kindred methods (*e.g.*, Donné with his lactoscope) determined the thickness of the stratum of undiluted milk through which the flame of a candle can be distinctly seen.

Of the numerous instruments all constructed upon this supposition, one, the lactoscope of Feser (Fig. 100), has gradually superseded the others, in consequence of its cleanly and convenient manipulation; I will therefore content myself with describing it.

FIG. 100.—Feser's Lactoscope.

EXPLANATION OF TERMS.
Wasser = water.
Fett = fat.

In a wide transparent glass tube, *g*, slightly contracted below, there is sealed a small cylinder of opal glass, *m*, which is everywhere at the exact distance of 4·75 *mm.* from the external cylinder, and is graduated with black transverse lines. Into the glass cylinder, which is carefully cleansed and dried, there are poured, by means of the accompanying pipette, 4 *cc.* of milk, and spring water is added (in portions of 5 to 10 *cc.*), shaking vigorously each time, until the degrees are distinctly visible by reflected light. The quantity of water which has been added, or the corresponding volume of fat, is then read off on the graduation of the lactoscope.

Dietzsch has recently modified the instrument by placing only one mark on the outer glass cylinder. If to 4 *cc.* of milk water is then added up to this mark, the milk, if it contains more than 2·8 or 2·9 per cent. of fat—which Dietzsch takes as a minimum—must be so opaque that the black marks cannot be recognised. If they can be counted, the market inspector hands over the sample to the chemist for closer examination.

The use of Feser's apparatus is uncertain even for an experienced operator—evidently as other circumstances than the mere proportion of fat may come into question. Thus, as Vogel mentions, Feser himself with his apparatus found in a milk 3¼ per cent. of fat, whilst Vogel by the gravimetric process found only 1·69 per cent., or

about one-half. The opacity of milk is greatly increased by boiling, owing to a change in the albuminous corpuscules.

But even if there occur no particular difficulties, the apparatus must be pronounced little trustworthy. It presupposes, of course, uniform illumination, and a uniform judgment whether the marks are distinct or indistinct, &c. The black marks on the opal glass are in time washed away, so that more water must be added for their recognition.

What has been said of the lactoscope holds good—*mutatis mutandis*—of the other optical methods. No one at present would venture in a law court to give an opinion on the proportion of fat in a milk in reliance upon an optical examination.

Still more deceptive than the results of the optical method are those obtained with the cremometer. It was sought to ascertain the percentage of fat from the depth of the stratum of cream which separates out in a measuring cylinder when the milk is left at rest for twenty-four hours. But the cream separates out from the milk sometimes not at all, sometimes imperfectly, and often very slowly; the cream is sometimes rich and at other times poor in fat. For particulars see Vogel and Herz. The manifold modifications of the simple cremometer are by no means improvements capable of making the apparatus useful for the purposes of the sanitary police.[1]

§ 276. A process which stands at the limit of an accurate determination and valuation is that with the lactobutyrometer, invented by Marchand, subsequently improved by Salleron and then by Tollens and Schmidt.

Principle.—The method depends on the idea of extracting the milk-fat from the liquid milk by means of ether, separating the fat from its ethereal solution by alcohol, and calculating the percentage of fat from the volume of fat thus separated.

Execution.—Into a glass tube holding 40 *cc.*, and sealed at the bottom (Fig. 101), there are introduced 10 *cc.* of milk by means of a pipette, then 10 *cc.* of ether (of the specific gravity

[1] It is to be regretted that the lactometer is still recommended in manuals for medical officers of health. See Wanklyn's "Milk Analysis," p. 8.—*Editor.*

0·725 to 0·730 at 15°); the tube is then stoppered with a soft cork well pressed, and well shaken; the cork is then cautiously eased and the shaking repeated until a perfectly homogeneous mixture is obtained. We then add 10 *cc.* of alcohol at 91 per cent. (specific gravity 0·8203), and the whole is again well shaken for a longer time (some minutes) until the clots of caseine formed are finely and uniformly divided. The tube, firmly closed, is then placed for at least a quarter of an hour in a tall, wide cylinder full of warm water at 48°, when a clear yellowish layer of fat separates out at the surface of the liquid. Drops of fat which rise more sluggishly can be made to unite with the main mass by gentle tapping. When the operation is completed the ethereal fatty stratum (about 1 *cc.*) must rise sharply and distinctly above the remaining liquid. The apparatus is then placed for a time in water at 20°, when some portions of fat which were held back by the warmer liquid mixture separate themselves, and the cubic centimetres of fat liberated are read off.

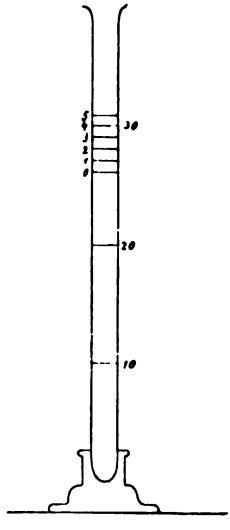

FIG. 101.—Lactobutyrometer.

Various authors recommend the milk to be first shaken up, before adding the ether, with from three to five drops of acetic acid, or with one drop of soda-lye, in order that the fat may be more readily taken up by the ether.

Table for the Lactobutyrometer. By Tollens and Schmidt.

A. $\frac{1}{10}$ cc.	B. Percentage of Fat.	A. $\frac{1}{10}$ cc.	B. Percentage of Fat.	A. $\frac{1}{10}$ cc.	B. Percentage of Fat.
1·0	1·339	4·5	2·053	8·0	2·767
1·5	1·441	5·0	2·155	8·5	2·869
2·0	1·543	5·5	2·257	9·0	2·971
2·5	1·645	6·0	2·359	9·5	3·073
3·0	1·747	6·5	2·461	10·0	3·175
3·5	1·849	7·0	2·563	10·5	3·277
4·0	1·951	7·5	2·665	11·0	3·379

Table for the Lactobutyrometer—continued.

A. $\frac{1}{10}$ cc.	B. Percentage of Fat.	A. $\frac{1}{10}$ cc.	B. Percentage of Fat.	A. $\frac{1}{10}$ cc.	B. Percentage of Fat.
11·5	3·481	15·0	4·195	18·0	4·956
12·0	3·583	15·5	4·297	18·5	5·129
12·5	3·685	16·0	4·399	19.0	5·306
13·0	3·787	16·5	4·501	19·5	5·483
13·5	3·889	17·0	4.628	20·0	5·660
14·0	3·991	17·5	4·792	20·5	5·837
14·5	4·093				

The columns B show directly what percentage of fat the milk contains when the quantities of the ethereal fat solution are read off in columns A.

The method gives generally not only approximate values but even very good results, but in many cases it fails us. If the milk contains less than 2·9 per cent., the method, according to Tollens and Schmidt themselves, is not quite trustworthy (for skim-milk it is therefore generally useless); if it contains more than 3·5 per cent. of fat we may, according to Fleischmann, obtain errors up to 1 per cent. Sometimes there occurs no separation at all of a fatty layer, or one which is too low by one-half. In spite of this undeniable faulty side of the method, it is recommended where there is no balance and no Soxhlet apparatus available, especially if we have to do with the control of numerous kinds of milk presumably normal (*e.g.*, in dairies for the control of contractors who supply milk). If a remarkable result is obtained with the method, one of the processes of the following section is to be used, but not much time is lost:—

The "lactocrit" of De Laval is a centrifugal apparatus, driven by steam, in which samples of milk warmed, and with the addition of a mixture of lactic acid and sulphuric acid, are made to revolve with extreme rapidity for three to four minutes; the percentage of fat can then be read off at once. Suitable only for use on the large scale in dairies.

B. Accurate Methods for the Determination of Fat.

§ 277. 1. *Gravimetric Determination of Fat.*—The proportion of fat is ascertained accurately by the following methods:—

1. The residue of the milk desiccated upon sand or gypsum [1] (§ 274), after it has been finely pulverised, is put in a paper case, extracted with ether, and the fat obtained is weighed according to § 214.

Latterly, the Adams method, the absorption of the milk by paper spirals, is universally recommended as very good. Specially prepared filter-paper (exhausted with alcohol and ether) is here employed. Of this material a slip of 56 *cc.* in length and 6 *cm.* in breadth is coiled loosely into a spiral,[2] held together by two rings of platinum wire; the coil is then dried in the desiccating closet and weighed (*a*). About 5 *grm.* of milk are weighed off in a small covered beaker, the spiral is allowed to absorb the milk all but traces, and weighed back into the residue of milk. The spiral is lifted out by the upper platinum ring, or by the twisted place which it has occupied, and dried on a porcelain capsule at 100° for one hour. The fat is then extracted with ether in Soxhlet's apparatus and weighed (*f*). The extracted paper spiral is also weighed (*e*). Then $e + f - a$ is the dry substance present in the quantity of milk absorbed.

The method of Adams constantly secures more advocates, and will completely supersede the tedious sand or gypsum method. The results agree excellently with those of Soxhlet's aræometric method, but are slightly higher (more correct than those of the gypsum method). The earlier objections against the Adams process, depending on the use of a material imperfectly extracted with alcohol and ether, are done away with.

2. Recently E. Pfeiffer has proved that by the careful execution of an older process (Hoppe-Seyler's) fairly concordant values are obtained for the fat. As this method is simple and convenient it is here described in the author's words:—

[1] For the determination of fat in skim milk gypsum is urgently advocated. 35 *grm.* of the finest gypsum and 10 *grm.* of milk are dried upon the water-bath without stirring; the dry mass obtained is weighed, ground very finely, and extracted.

[2] Schleicher and Schüll offer for sale a suitable paper in proper coils.

About 10 *grm.* of milk are weighed, mixed with 40 *cc.* of distilled water, and there are added 3 or 4 *cc.* of a 2 per cent. hydrochloric acid (2 *cc.* of the pure concentrated hydrochloric acid with 100 *cc.* of water). The flocculent precipitate formed on stirring is immediately placed on a folded filter of 9 *cm* in diameter, which has been previously extracted with ether, slightly washed with water, and then dried in the desiccation closet from five to six hours. The dried filter is then bent together at the top and extracted with ether, according to § 214. The loss of weight after desiccation shows the proportion of fat.

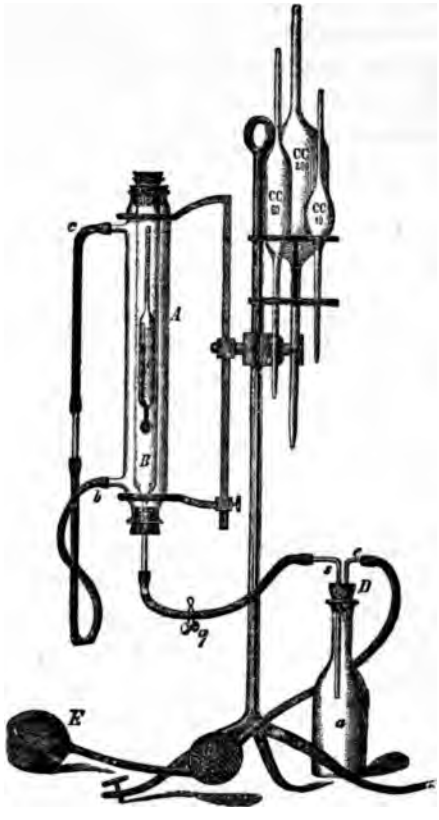

FIG. 102.—Soxhlet's Apparatus for the Areometric Dteremination of Fat.

For the examination of human milk the method of E. Pfeiffer is modified as follows:—About 10 *grm.* of milk are weighed off as rapidly as possible in a small beaker, and mixed with about 10 *cc.* of absolute alcohol. On stirring there appears at once a very finely divided precipitate, which is immediately placed upon a folded filter of 9 *cm.* in diameter, previously extracted with ether and alcohol. The residue of the precipitate is very carefully rinsed out of the beaker with a portion of the filtrate, and the beaker itself finally cleansed out with a mixture of 10 *cc.* distilled water and 10 *cc.* absolute alcohol, using the caoutchouc scrubber, and the precipitate is then washed upon the filter with the same liquid. The funnel with the filter and precipitate is after washing placed imme-

diately in the drying-closet, where it is allowed to remain for three to four hours. Then follows extraction in Soxhlet's apparatus.

If a determination of albumen in the milk is made according to Ritthausen (§ 279), the fat may be determined by extracting the copper precipitate, a manipulation which must in any case be carried out for determining the albumen.

A series of my own determinations, with hydrochloric acid as well as Ritthausen's precipitation, have afforded me accurate results, so easily obtained that I may recommend the method especially for any one who works without extensive apparatus.

2. *The araeometric method of determining the fat according to Soxhlet.*

§ 278. Along with the chemical methods above described, a physical process, devised by Soxhlet, and elaborated in its minutest details, has latterly met with universal acceptance. It is now regarded as the best method for the determination of fat, but it unfortunately requires a somewhat costly apparatus.

On account of the advantages of the method, and of the rapidity with which the apparatus admits of the successive completion of very many determinations of fat, it is indispensable for every one who performs many examinations of milk. A scrupulously accurate observance of what seem to be the most unimportant details of the instructions is necessary for correct work, especially as regards the manner of shaking and the maintenance of the temperature.

Principle.—The principle is that ether, if mixed in certain quantities with milk and potassa-lye, dissolves all the fat of the milk, and that at a given temperature a perfectly definite specific weight corresponds to every percentage of fat in the ethereal solution of fat.

For the performance of the process there are required (*verbatim* according to Soxhlet):—

1. The apparatus as figured with the three accompanying tubes for measuring milk, potassa-lye, and ether, which can be fixed on the stand of the apparatus, and several shaking-flasks (*a*).

2. Potassa-lye of specific gravity 1·26 to 1·27.
3. Washed ether (which has been shaken up with distilled water).
4. Ordinary ether.
5. A vessel of the capacity of at least 4 litres, with water which must be brought to the temperature of 17° or 18°. For the simultaneous execution of several experiments the vessel must be correspondingly large. If the room is warm 17° is taken as the initial temperature, if cooler, 18°.

The execution of the process :—Measure off 200 *cc.* of the milk, which must have been thoroughly mixed and cooled (or warmed) to 17½° (17° or 18°), by sucking the largest pipette full up to the mark ; the contents of the measuring-tube are allowed to flow into one of the shaking-bottles (*a*) of the capacity of 300 *cc.*, and the measuring-tube is finally emptied by blowing into it.

In a similar manner 10 *cc.* of potassa-lye are measured off with the smallest pipette, shaking well up, and adding 60 *cc.* of washed ether which has been measured off in the corresponding pipette. The ether, when measured in, should have a temperature of 16·5° to 18·5° (normally 17·5°). After the flask has been well closed with a cork or a caoutchouc stopper it is shaken up violently for half a minute, placed in the vessel with water at 17° to 18°, and during a quarter of an hour it is very gently shaken every half minute, giving each time three or four shocks in a vertical direction. After standing quietly for a quarter of an hour longer, a clear layer will have collected in the upper contracted part of the bottle. The collection and clarification of this layer is accelerated if towards the end of the time a slight rotatory movement is given to the contents of the bottle. It is indifferent whether the entire solution of the fat has collected on the surface or only a portion, if it is large enough to allow the hydrometer to float. The solution must be perfectly clear. In milk very rich in fat (4½ to 5 per cent.), the separation takes a longer time than that mentioned above—sometimes, exceptionally, from one to two hours. In such cases, and indeed generally, if a sufficiently large water-vessel is at hand, it is judicious to lay the bottles—which must be well corked—horizontally.

The apparatus for the determination of specific gravity, shown in Fig. 102, is arranged as follows :—

The stand carries, by means of displaceable nuts, a support for the cooling-tube *A*, to the efflux-tubes of which are fixed short caoutchouc pipes. The support of the cooling-tube can rotate on its perpendicular axis, so that it may be placed in a horizontal position. A glass tube, *B* 2 *mm.* wider than the float of the areometer, is fixed centrically in the condensing-tube. In order to prevent the upper part from being closed by the areometer, or to prevent the latter from wedging fast, there are at the lower part of *B* three points projecting inwards. The upper, open end must be closed with a cork.

The areometer *C* has on the scale of its stem the degrees 66 to 43, which at 17½° C. correspond to the specific gravities 0·766 to 0·743.

In the float of the areometer there is a thermometer, graduated in

fifths of a degree Centigrade, by means of which one-tenth of a degree can be read off.

For use, the caoutchouc pipe of the lower lateral outflow-tube, *b*, on the cooling-tube, is plunged into the vessel of water, suction is applied at the upper flexible pipe until the intermediate space of the cooler is filled with water, and the whole is closed by uniting the ends of both flexible pipes by means of a small glass tube. The stopper *a* of the shaking bottle is removed, in its place is fixed the cork *D*, through the two apertures of which there pass elbow-tubes of different lengths, the longer-limbed one, *s*, being pushed down so far that its end almost plunges into the layer of ether-fat. After the small caoutchouc bag has been fitted on the shorter elbow-tube, and the cork in the tube *B* has been eased, the pinch-cock *q* is opened, and the caoutchouc ball *E* is pressed as gently as possible. The clear solution of fat rises into the araeometer tube and lifts the araeometer. When the latter floats, the pinchcock is closed, and the cock fixed in the araeometer tube to prevent the ether from evaporating. The operator waits for one or two minutes, until the temperature has become equalised, and the height of the scale is read off, but not until the araeometer has been brought into the middle of the liquid, which is easily effected by inclining the elbow-tube on its movable holder, and turning the screw at the foot of the stand.

As the specific gravity is reduced by a rise of temperature and is raised by a lower temperature, the temperature of the ethereal fat-solution must be taken into account in determining the specific gravity of the ethereal fat solution. We therefore, shortly before or after the reading of the araeometer, take the temperature of the liquid to one-tenth of a degree on the thermometer in the araeometer. If the temperature was exactly 17·5°, the indication of the araeometer is at once available, otherwise the specific gravity read off must be reduced to the temperature of 17·5°. For every degree which the thermometer indicates above 17·5° a degree must be added to the figure read off on the araeometer, and for every degree which it shows less than 17·5° a degree must be deducted ; but the deviation from the mean temperature 17·5° should not exceed 1°. From the specific weight found for 17·5° the proportion of fat may be found in percentages by weight on reference to Table XII.

Example.—Specific gravity of the ethereal solution of fat at 17·0° = 57·0 ; therefore at 17·5° = 57·0 − 0·5 = 56·5. To this specific gravity the corresponding proportion of fat is 3·69 per cent.

In order, after the completion of an investigation, to have the apparatus ready for the next determination, the cock of the shaking-bottle is eased, and the solution of fat is allowed to flow back into it. The araeometer-tube *B* is then filled with ordinary ether, and this also is allowed to flow off. If a powerful current of air is driven through the entire apparatus by means of a blast, it is quickly obtained clean and dry. In case of need it is again rinsed out with ether.

4. DETERMINATION OF THE ALBUMENOIDS.

§ 279. In general a determination of nitrogen by the Kjeldahl process (§ 213) is sufficient for the estimation of the albumenoids; they are rarely determined as such. We shall therefore describe merely the excellent method proposed by Ritthausen. We prepare: 1. Solution of copper sulphate, 34·64 crystalline copper sulphate per litre, *i.e.*, the stock-liquid of Fehling's solution (§ 215) diluted with an equal volume of water. 2. Soda-lye, 15 *grm.* caustic soda per litre. Specific gravity 1·0180.

We weigh out 10 *grm.* of milk, add 100 *cc.* of water and exactly 15 *cc.* of solution of copper sulphate, and stir, adding then 7 *cc.* soda-lye and stirring again. Almost always there appears in a few moments a light-blue, finely flocculent precipitate, which quickly subsides, and over it a clear, colourless, neutral liquid, free from copper and albumen. The precipitate is collected on a weighed folded filter, dried, weighed again, extracted with ether in Soxhlet's apparatus (determination of fat by observing the decrease of weight). On weighing: filter + albumen + copper hydroxide (the copper on the filter is in this state) = A, the filter alone = F. Then $A - F = 0{\cdot}2026$ albumen, for the hydrated copper oxide from 15 *cc.* of solution of copper sulphate weighs 0·2026. For very accurate determination there are to be deducted, according to Pfeiffer, from 16 to 19 *mgrm.* for constituents of the ash of milk which have been simultaneously precipitated.

If, on working carefully according to the above directions, there appears, instead of the light-blue, finely flocculent precipitate, a dark-blue sediment of large flocks, the reaction must be examined. If alkaline, it is very cautiously diluted with highly dilute hydrochloric acid; if acid, the above soda-lye is added drop by drop. For further details see Pfeiffer.

On the fractionated precipitation of the albumenoids compare § 271.

5. DETERMINATION OF LACTOSE.

§ 280. The filtrate from Ritthausen's precipitation of albumen, which is free from albumen, fat, and copper, is diluted to 400 *cc.*, and treated according to § 279.

6. DETERMINATION OF ASH.

§ 281. The residue from the determination of solids effected in a platinum capsule on C. Pfeiffer's method is conducted according to the rules given in § 274. An addition of sodium carbonate or bicarbonate cannot be distinctly detected gravimetrically, as 1 *grm.* of soda-ash per litre gives milk an alkaline taste, although the ash is increased only from 0·75 to 0·85 per cent. The ash of pure milk is very faintly alkaline, but that of milk to which ordinary soda or bicarbonate has been

added has a very strong alkaline reaction. In incinerating milk i is very important to avoid an excessive heat.

The detection of an addition of soda is more practically effected a according to § 283 than in the ash.

Heavy metals are sought for according to Section XVIII.

7. DETERMINATION OF THE REACTION AND THE ACIDITY OF MILK.

§ 282. Milk freshly drawn from the udder has always a amphoteric reaction, *i.e.*, it can both redden blue litmu paper and turn reddened paper blue. But here a ver sensitive pale neutral litmus paper is required. This pro perty is due to the presence of mono-potassium phosphat (H_2KPO_4) with an acid reaction, along with (HK_2PO_4) wit a faintly alkaline reaction with litmus.

With phenolphthaleine which shows a violet colour onl with basic substances or an excess of alkali, milk behave like an acid, and we may determine the degree of acidity b the volume of soda-lye which must be added to produce violet colour. On standing the acidity increases by th formation of lactic acid, and accordingly the increased con sumption of soda-lye. Two methods of titration have bee proposed.

Method of Soxhlet and Henkel.—50 *cc.* of milk which ma be measured + 2 *cc.* of an alcoholic solution of 2 per cent solution of phenolphthaleine are titrated with one-fourt normal soda-lye. For 100 *cc.* of fresh milk there wer generally consumed 7 *cc.* of this soda-lye for the productio of a faint rose-colour. At Würzburg we generally found fo fresh market-milk from 9 to 9·7 *cc.* If comparable value are to be obtained the milk must not be diluted with water as in this case (according to Söldner) less lye is consume for the same quantity of milk for the production of a rose colour.

Plaut (*Archiv f. Hygiene*, xi.), according to a very carefu investigation, containing numerous valuable details, alway mixes 25 *cc.* of milk and 1 *cc.* of Soxhlet's solution o phenolphthaleine and titrates with baryta-water, of whic

1 *cc.* = 5 *mgrm.* SO_3. On using baryta-water he always has rather higher acidities than with soda-lye, and more accurate final reactions, by means of which, *e.g.*, he was able to demonstrate a distinctly reduced acidity in fresh milk after a short ebullition, in consequence of the escape of carbonic acid. He generally found from 85 to 95 *mgrm.* of acid (calculated as SO_3) in 100 *cc.* of *fresh* milk, but after boiling about 10 *mgrm.* less. On standing the CO_2 which has been absorbed slowly escapes.

E. Pfeiffer proposes to dilute 10 *cc.* of milk (it is here sufficient to measure) with 40 *cc.* of water, adding a few drops of a concentrated solution of phenolphthaleine in alcohol at 50 per cent., and dropping in cautiously decinormal soda-lye until a pale rose-colour appears. Or 0·8 to 0·9 *cc.* of one-fourth normal soda for fresh milk. (See Dissertation, by J. Clauss, *Bakteriolog. Untersuch. der Milch in Würzburg*, &c., 1889.)

According to our experiments for 100 *cc.* of undiluted milk, there is required about twelve times as much soda-lye as for 10 diluted to 50 *cc.* Titration after dilution, according to Pfeiffer, is more pleasant, as the change of colour is more prompt and the consumption of milk smaller. But since Plaut also has carried out all his numerous analyses according to Soxhlet's method, the choice of this latter process is to be recommended.

8. DETECTION OF PRESERVATIVE AGENTS AND OTHER CHEMICALS ADDED.

§ 283. The true preservative agents (benzoic acid, salicylic acid, boric acid) are with us rarely added to milk. Their detection is treated of in § 226. Salicylic acid, if added rather freely to milk, may be detected by a slight addition of ferric chloride. An especially prominent part is played by sodium carbonate and bicarbonate in improving milk, although both these additions do not prevent the formation of acid, but merely hinder such acid from coagulating the milk. The neutralisation of the acids formed even promotes

the production of a fresh supply. The detection of any appreciable quantity of soda is easy and distinct.

Lazarus (*Zeit. f. Hygiene*, viii.) showed that heating for one or two hours to 100° is sufficient as a preliminary test. Milk with alkaline additions (soda, sodium bicarbonate, lime, borax) takes a brown or brownish-red colour; the colour taken by unsophisticated milk is at most very slight.

E. Schmidt's Method.—10 *cc.* of the milk in question are mixed with 10 *cc.* of alcohol, and with a few drops of a 1 per cent. solution of rosolic acid. Pure milk assumes merely a brownish-yellow colour, whilst milk containing sodium carbonate or bicarbonate appears more or less of a rose-red colour. An addition of 0·1 per cent. of sodium bicarbonate can be detected in this manner with great distinctness if the same test is simultaneously applied for comparison with normal milk. Phenolphthaleine is not applicable for this purpose.

For a quantitative determination of the bicarbonate added the method of Padé is greatly recommended, and may be consulted in the *Chemiker Zeitung*, 1889. Repertorium, 228.

9. CHEMICAL EXAMINATION OF CURDLED MILK.[1]

§ 284. It may occur that milk arrives in the laboratory which has curdled in transit. In this case we seek to procure a fresh sample; the curdled milk is well shaken up in the bottle, a part of it is poured upon a filter, and in the filtrate (milk-serum) the specific gravity is determined (§ 20); it should not fall below 1·027. (Compare Radulisou, *Chemiker Zeitung*, 1890, No. 50.) To the residue in the bottle there is added some concentrated ammonia until it slightly predominates; the bottle is shaken again, and its contents, the total solids and the fat, are determined gravimetrically, taking into consideration the possible presence of lactic acid in the weighed fat. The filtered serum, after the determination of its specific gravity, is tested for metals,

[1] For some remarks on the examination of milk for poisons, see § 297.

which may have been introduced on standing in metal vessels or in such as are badly glazed (§ 297).

10. BACTERIOLOGICAL EXAMINATION OF MILK.

§ 285. Milk from a healthy cow is secreted free from microbia; but microbia always find their way into the milk from the surface of the udder, from the hands of the milker, from particles of dung, from the milk-cans which are never free from microbia, and, finally, from the air of the cow-house, which very rapidly multiply if the milk is not at once exposed to very low temperatures.

Recently Leopold Schulz, working in my laboratory, has observed that the residues of milk in the excretory ducts of the udder present one of the most important sources of infection for milk. Fractionated milking shows a rapid decrease of the number of microbia in the portions successively drawn: *e.g.*, the first 300 *cc.* contained per cubic centimetre 75,000 microbia, an intermediate portion 10,000, whilst the last portion was sterile. If a milk is diluted with water a crop of bacteria is thus obtained.

The method of examination is that customary for liquids. Smear-preparations on cover-glasses may be splendidly dyed, according to Arens (*Centralblatt f. Bakteriologie*, x.) by placing the dried and *flambé* cover-glasses in a small capsule containing 5 *cc.* chloroform and 1 *cc.* of a saturated alcoholic solution of methylene blue. After five minutes the chloroform is allowed to run off and evaporate, the glasses are rinsed with water, and there is thus obtained an isolated coloration of the bacteria with the ground at most of a pale blue.

More important is the examination by cultivation; on account of the great number of micro-organisms plentiful dilution is necessary, and agar should be used for the plates. In cases of new milk 5 *cc.* of milk should be first added to 100 *cc.* of sterilised water, and of this again 1 *cc.* to 100 *cc.* of sterilised water, and plates prepared from the first and second dilution with 0·5 and 1·0 *cc.* The number of microbia of the plate multiplied by 2121 gives the number

of microbia in 1 *cc.* Milk which has been exposed for some time to a higher temperature must be diluted from ten to fifty times more strongly. If the several kinds have to be isolated from the milk, a still greater dilution may be necessary.

By this method Clauss, in my laboratory, found in new Würzburg milk, bought at 8 A.M. on a winter morning, from the dairymen, or from the peasants who supply milk, and preserved in a sterilised vessel for at most thirty minutes to one hour before a window secured with wadding, from 1·2 to 2·3 million schizomycetes (on one occasion only as few as 220,000); Hohenkamp found in summer 1·9 to 7·2 millions. If the milk is exposed to a temperature of about 25° the number of microbia increases in twenty-four hours from 1 to 2000 times, at 10° about 20 times; at temperatures a little above 0° there ensues an unimportant increase; temperature below 0° diminishes the number of microbia to two-thirds (Clauss).

The species commonly found in milk are: *Bacillus acidi lactici* (§ 84), *Bacillus butyricus* (Hüppe); Clauss found regularly at Würzburg two white cocci which do not liquefy gelatine—*Fluorescens liquefaciens*, and a "fan-bacillus" resembling the bacillus of lactic acid. One kind of coccus left the reaction of milk unaltered, the other occasioned a slight formation of acid; whilst the bacilli of lactic acid, *Fluorescens* and the fan-bacilli, produce acid of about equal strength. Compare Leopold Schulz (Dissertation, Würzburg, 1891), who obtained somewhat discrepant results. Grotenfeld describes also an anærobic Streptococcus which produces lactic acid.

Loeffler examined milk which had been slightly boiled and stoppered with wadding, but had gradually passed into decomposition. He found purely sporiferous bacilli which attacked and peptonised albumen, and gave rise to an alkaline reaction, among which were *Bacillus mesentericus vulgatus* and *liodermos* (§ 84).

Blue milk contains *Bacillus cyanogenus* (§ 84), red milk *Bacillus prodigiosus*, or the bacillus of red milk (§ 84), or the quite recently discovered *Sarcina rosea* (*Cent. f. Bakteriologie*, vi. 596). Yellow milk is produced by *Bacillus synxanthus* (Flügge, *Mikroorganismen*, p. 290). Milk is rendered slimy and capable of being drawn into threads by a short, thick bacillus, which has been studied by Schmidt-Mühlheim and Loeffler, and which is inclined to resolve itself into coccus-like segments. The slime seems in part to be a gummy carbohydrate formed from milk-sugar by the activity of microbia, but it consists in part of the metamorphosed bacterial protoplasm. More recent researches show,

moreover, that various micro-organisms render milk stringy; thus micrococcus occasion "*die lange Wei*" in Holland (*Milchzeitung*, 1889, pp. 421, 955), whilst Adametz describes a *Bacillus lactis viscosus* (*Milchzeitung*, 1889, p. 941; *Centralblatt f. Bakteriologie*, vii., viii., ix.). In his latest investigations (quoted *Centralblatt f. Bakteriologie*, ix. p. 698) Adametz already enumerates eleven species which render milk stringy; a part of them, however, may be mutually identical. The subject of the decomposition of milk by schizomycetes and other organisms is being very carefully studied, and many new results may be expected.

Numerous microbia communicate a bitter taste to milk, as we may easily convince ourselves by tasting old milk-cultures of different bacteria. This is especially the case among three microbia which have not hitherto been described, among which are a coccus, a bacillus, and the *Proteus vulgaris* (*Centralblatt f. Bakteriologie*, ix. 653).

All these micro-organisms find their way into the milk only after milking. Under certain circumstances pathogenic microbia (species producing typhus, cholera, suppuration, &c.) may be present in milk, and may increase in it to a certain extent (see § 300).

The milk of diseased animals may contain a series of pathogenic organisms, especially the bacilli of tubercle, cocci producing suppuration, &c. The detection of tubercle bacilli by staining generally miscarries; it is much more certain to inject from 10 to 15 *cc.* of the milk into the peritoneal cavity of a guinea-pig. The milk must be as fresh as possible. About four weeks after the injection the animals are killed, when there appears the characteristic type of tuberculosis of the peritoneum. Concerning *Monilia candida* see § 91; it may be readily detected by plate-cultures.

11. DETERMINATION OF DIRT IN MILK.

Renk has proposed the following simple practical method (*Münchner. Med. Wochenschrift*, 1890, Nos. 38 and 3). The milk in question is well stirred up or shaken, and 1 litre is poured into an ordinary glass mixing cylinder. After two hours the dirt will have been deposited. The milk is slowly drawn off through a syphon of glass and caoutchouc down to about 30 *cc.*, without stirring up the sediment. The glass is then filled up with spring water to 1 litre, and the sedimentation and syphoning are repeated until the residue lies in perfectly clear water. It is then collected upon a dried and weighed filter, which is weighed again after repeated drying.

The figures found give the dry substance, and in order to recalculate it as recent cow-dung we must remember that the latter never contains more than 20 per cent. of dry sub-

stance, whence the residue as a minimum must be multiplied by five. The following values have been found hitherto in hygienic institutes, as determined in 1 litre milk:—

Wurzburg.		Leipzig.		Munich.		Berlin.		Halle.	
Mean.		Mean.		Mean.		Mean.		Mean.	
Dry Substance.	Fresh Substance.	Dry Substance.	Fresh Substance.	Dry Substance.	Fresh Substance.	Dry Substance.	Fresh Substance.	Dry Substance.	Fresh Substance.
Mgrm. 3·02	Mgrm. 15·1	Mgrm. 3·8	Mgrm. 19·0	Mgrm. 9·0	Mgrm. 45·0	Mgrm. 10·3	Mgrm. 51·5	Mgrm. 14·92	Mgrm. 74·60
Maximum.		Maximum.		Maximum.		Maximum.		Maximum.	
Dry Substance.	Fresh Substance.	Dry Substance.	Fresh Substance.	Dry Substance.	Fresh Substance.	Dry Substance.	Fresh Substance.	Dry Substance.	Fresh Substance.
Mgrm. 8·1	Mgrm. 40·5	Mgrm. 11·5	Mgrm. 57·5	Mgrm. 27·9	Mgrm. 139·5	Mgrm. 50·0	Mgrm. 250·0	Mgrm. 72·5	Mgrm. 362·5 !

12. ON THE CONNECTION BETWEEN THE COAGULATION OF MILK AND THE EXTERNAL CONDITIONS.

§ 286. Milk of medium keeping properties (*i.e.*, of medium impurity at a normal composition), coagulates, according to Soxhlet, at 35° in 19 hours, at 30° in 21 hours, at 25° in 29 hours, at 20° in 48 hours, at 17½° in 63 hours, at 15° in 88 hours, at 10° in 198 hours.

Whilst 100 *cc.* of milk freshly purchased from the dealers required at Würzburg, according to Soxhlet, about 9·5 *cc.* of one-fourth normal soda-lye for neutralisation, milk at the beginning of coagulation required 30 *cc.*; if it had passed into gelatinous coagulation, about 34 *cc.*; and if it had become curdy, 37 to 43·8 *cc.* of the same one-fourth normal soda-lye.

The degree of acidity in milk (the most convenient scale for decomposition), if it has been at once cooled, remains for some time evidently constant (incubation-stage, according to Soxhlet); at 10°, milk of medium keeping property remains from 52 to 72 hours without perceptible change in the acidity; at 15°, 36 hours; and at 35°, from 3 to 8 hours.

The time of incubation evidently means that the perceptible action of the schizomycetes begins only when they have sufficiently multiplied, which at different temperatures re-

quires different lengths of time. If to freshly drawn milk we add small quantities of sour milk rich in bacteria, the incubation and the time of coagulation are much abridged.

The chief cause of the coagulation of milk is the formation of lactic acid (§ 285).

Coagulation is produced, according to Segelke, by 0·55 to 0·60 per cent. of free lactic acid at the temperature of a dwelling-room, and by 0·20 per cent. not below the boiling-point.

The utmost cleanliness in milking, immediate and rapid cooling, and preservation at a low temperature, are consequently the fundamental conditions for a rational preservation of milk.

Methods of examining milk may here be mentioned which have been devised for cheese-factories, but certainly admit of a further application. (See Herz, *Kuhmilch.*)

1. *Schatzmann's Fermentation Test.*—Portions of milk of 100 *cc.* each, in sterilised glass jars with porcelain covers, are placed in a water-bath at 40°. At the expiry of six and nine hours respectively, milk must give no signs of fermentation, coagulation, &c. If coagulation appears at the expiry of twelve hours, the milk is to be regarded as suspicious.

2. *Schatzmann's Caseine Test.*—If 100 *cc.* of milk are mixed with 2 *cc.* of a solution of rennet of a known concentration (1 tablet of rennet in 500 *cc.* of water), the milk, in a water-bath at 35°, coagulates not sooner than in ten and not later than in twenty minutes. Colostrum and milk turning sour curdle in seven to eight minutes, saline milk later or not at all, the milk of feverish beasts slowly. In inflammation of the udder (mastitis), the coagulum is flocculent, not compact, &c.

From the above two methods Diethelm has combined a third, especially useful in the manufacture of cheese, but less so in hygiene (Cheese-fermentation test).

13. DISTINCTION BETWEEN UNBOILED AND BOILED MILK.

§ 287. 1. Unboiled milk turns tincture of guaiacum blue, boiled milk does not. According to Arnold, this depends on the presence of ozone.

2. On boiling milk, there is, according to Schreiner, an escape of sulphuretted hydrogen. Boiled milk contains none. The smell and taste are perceptibly modified by boiling.

3. Before boiling (according to Schreiner), milk requires

for coagulation 10 to 12 per cent. more of sulphuric acid at 0·1 to 0·2 per cent., than after.

4. Boiling increases the opacity of milk very considerably, evidently by a change in the aggregation of the swollen and dissolved albumenoids. This also occasions the formation of a film on boiling.

APPENDIX TO SECTION A.—EXAMINATION OF MILK.

§ 288. **The Examination of Milk by the Market Inspectors.**—In order to facilitate the control of milk, in almost all towns police officers or especial market inspectors are entrusted with a preliminary examination. These persons are instructed to examine the milk of the dairymen and milk-dealers at irregular intervals with the Quevenne aræometer (milk-glass), and, if needful, with Feser's or Dietzsch's lactoscope, with which instruments they are supplied. If the aræometer is used, the milk must be well stirred up in the sale-can, which must be properly marked, poured into a suitable glass-cylinder (hydrometer-jar, eprouvette), and the temperature read off according to the Centigrade scale. For every degree of temperature above 15° C., 0·2° must be added to the reading of the aræometer; for each degree below 15° C., 0·2° must be subtracted, as tables of corrections scarcely come into the hands of the police. If the market inspector finds new milk marking below 30° or above 34°, skim milk below 33°, or milk from a centrifugal machine below 33·5°, the milk is to be characterised as suspicious; from ½ to ¾ litre are to be filled into a *clean* dry bottle, closed with a clean new cork, the projecting end of which is cut off, and the bottle is at once sealed up and sent to the public analyst. A ticket is attached with the following particulars: Date (day and hour), the degree of the lactodensimeter read off, the temperature observed, the number of the lactodensimeter (the correction table for which is kept by the analyst), any observations made as to abnormal appearance, odour, or taste of the milk; finally, the name and address of the vendor, along with his statements concerning its source, time of milking, state of health of the

cows, their time of feeding, and the supposed cause of the inferior condition of the milk.

Where the market inspectors are entrusted also with lactoscopes, they must, in cases where a watery appearance, along with a normal specific gravity, give ground for suspecting a combined sophistication, make the attempt to arrive at the truth by the optical method (the minimum of fat required varies in different places from 2·5 to 3 per cent.). But it is always well for the analyst to examine *every* sample of milk which appears suspicious to an experienced market inspector rather than to trouble the police with methods of testing the untrustworthiness of which has been long ago demonstrated. From time to time the milk of all the dealers and peasants should be chemically examined.

B. Normal Composition of Milk, and its Fluctuations owing to the Breed of the Cattle, the Food, &c.

§ 289. Milk as obtained by completely draining the udder of a cow is called new milk (full milk, entire milk); in general the new milk of several cows comes to market mixed as market milk, in which the individual differences of the milk of the several cows are compensated. According to the market regulations of most German towns, new milk must be sold in tin vessels distinctly marked V.M. or M.; in like manner, milk which before sale has been skimmed to obtain the cream must be marked as skimmed milk (A.M.), whilst milk almost entirely deprived of cream in a centrifugal machine is marked as centrifugalised milk or "whizzed" milk.

The composition of new milk is:

	Limits.	Average.		
	Medicus.	Dietzsch.	König.	Fleischmann.
Water . .	83·65–90·0	87·5	87·17	87·75
Fat . .	2·80– 4·5	3·5	3·69	3·40
Caseine . .	3·00– 5·0	3·5	3·55	3·60
Albumen .	0·30– 0·6			
Milk sugar .	3·00– 5·5	4·8	4·88	4·50
Ash . .	0·60– 0·8	0·7	0·71	0·75
Total solids	10·0 –16·35	12·5	12·93	12·25

The specific gravity at 15° is from 1·029 to 1·034.

It must in general be pointed out that the quantity of milk yielded by a cow, and its proportion of total solids and of fat, vary often in opposite proportions. It is certain, however, that the Dutch cows, which produce an abundance of milk, yield a much more watery milk (containing often only 2½ per cent. of fat) than other races which yield smaller quantities of milk. The dry substance free from fat which varies only from 7·8 to 10·2 per cent., fluctuates relatively less than the fat 2·5 to 4·5 per cent. In every district the analyst should collect observations on the average composition of milk for the several months; mean values for extensive districts or entire counties can serve only for arriving at a correct opinion.

Skim milk (milk deprived of cream) is always commencing to turn sour, as from twenty-four to forty-eight hours have to elapse before it is skimmed. The proportion of fat varies greatly; extreme figures cannot be given; the specific gravity amounts to from 1·032 to 1·033 and more, unless it has been simultaneously watered.

Centrifugalised milk, according to Fleischmann and Dietzsch, contains about from 0·2 to 0·6 per cent. of fat, and has a specific gravity of 1·0335 to 1·036.

Half-milk is unfortunately allowed to be sold in many places, *e.g.*, Berlin, Zurich; it consists of skimmed evening milk and new morning milk, or of milk which has been partially freed from cream. Its sale ought to be prohibited, since it creates a sort of milk not easily controlled, and of a condition not easily definable.

§ 290. Along with the above-mentioned differences depending on race, there occur variations in the composition of milk due to a series of influences hard to estimate. For conditions affecting the odour and the taste, see § 297.

1. The food exerts an influence if the cows are induced to take a very watery food not accompanied with sufficient dry substances, as distillers' refuse,[1] beetroot

[1] Schlempe is a name given to distillers' waste, varying according as grain, potatoes, or beet-root serve as the raw material. It consists of water (90 per

cuttings,[1] or doses of salt to create thirst. The milk then becomes very abundant, but it is as if watered in the body of the cow, and is simultaneously poorer in fat and in other solids. Some days generally elapse before the full effects of such a change of diet appear; they are rarely recognised before one or two days. Small changes in the food are often for a considerable time without important influence. On grazing in pastures the milk is rapidly rendered richer in fat than during stall feeding.

As for the different kinds of forage the following points are to be considered:—Every forage in a mouldy, putrescent, or even in an acid fermenting condition is injurious both to the cow and the milk. Hay (especially clover hay), green fodder from clover fields or good meadows, and all kinds of grain, are to be regarded as good. Mangolds, boiled potatoes, fresh or freshly dried brewers' grains, moderate quantities of malt sprouts, are also rational food. Raw potatoes, the leaves of potatoes, fruit and residues of fruit, the leaves, &c., of beets, and sour whey must be rejected. (According to the conditions of the Milk-suppliers' Association in the Algäu.)

The question of feeding with distillery waste, &c., is answered by König as follows: The residues from the starch manufacture and from treacle[2] are an unwholesome fodder, whether fresh or dried. Fresh grain and potato-waste, not sour, and fresh dried, are admissible, but milch-cows should not receive more than 20 litres of this fresh waste daily, otherwise the milk will be too watery and will occasion diarrhœa in children.

A certain chemical proof of the use of these substances can scarcely be produced. Smell and taste, an occasionally abnormal proportion of water, or its disagreement with the consumer, will furnish the experienced observer with a clue.

2. *Moderate work of cows* has no influence upon the milk. Very severe labour may cause the production of a quite abnormal milk containing little fat and dry matter but an increase of mineral substance.

3. The manner of milking is of great importance for the quality of the milk. In the udder of cows a separation of cream takes place exactly as in a vessel. Hence the portions

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cent.), cellulose, and albumenoid substances, with variable small quantities of unfermented starch or sugar.

[1] Beet-root cuttings are the exhausted residues of the beet-sugar manufacture.

[2] Probably the treacle from beet-sugar, which is unfit for food.—*Editor.*

of milk first drawn are poor in fat, and the last portions rich in fat. Schmidt-Mühlheim found in the first 500 *cc.* drawn from different cows 0·8, 0·6, 0·8, 0·6 in the portions first obtained, and in the last portions 5·6, 4·8, 5·1, 4·9 per cent. of fat, *i.e.*, about seven times as much as in the first portions.

Hence it follows that a good average milk can be obtained only if the udder is entirely emptied, and the milk obtained is well mixed. It is evident that in the establishments for the milk-cure the milking into the glass, still so much admired, yields milk of a very unequal composition, and is to be abandoned, a matter to which the physicians of these establishments should attend. Secondly, it must be at once pronounced a fraud when a producer of milk, *e.g.*, seeks to collect the last fraction of a milking separately,[1] and sells it as cream or uses it for the production of butter (Würzburg, "three groschen cream," according to Herz), whilst he sells the first portions (milk which has in a certain sense been already skimmed in the cow) as new milk. Fleischmann says very justly: "Every buyer of milk assumes tacitly that he obtains milk which represents the average produce of one cow or of several cows, and every seller acknowledges this supposition as a matter of course." The first couple of strokes should not be collected, but should serve in a manner to rinse out the excretory ducts, removing impurities and microbia which have entered

4. The time of milking has no distinct influence upon the quality of the milk if it is performed at exactly equal intervals of twelve hours, *i.e.*, evening and morning. If cows are milked three times daily, *e.g.*, morning, noon, and evening, the quantity of milk after the shorter intervals (therefore at noon and in the evening) is smaller, but its percentage of fat or of solids is rather higher. A cow, if milked on successive days at exactly identical times, gives milk of almost exactly identical composition even if her food has been changed; upon this fact depends the process of the *cow-house test*, § 294. Moderate differences may be produced by the manner of milking, by the physical condition of the cow, &c. Even a strange locality and an unaccustomed milker are said to have an influence.

5. The age of the cow or the number of calvings has an influence upon the milk which is but little understood. Cows are not allowed to conceive prior to their third year; pregnancy lasts 284 days. Colostrum is secreted for a short time before and after the birth, and then milk for 300 days. The quantities of milk after the several births increase from 1530 litres at the first to 2350 at the sixth, and decrease to 480 litres at the fourteenth (Fleischmann). A decided influence of the number of the pregnancies upon the composition of the milk has not been hitherto detected; aged cows often give strikingly inferior milk. The researches of Vieth, of England, carried out on an enormous

[1] Known in England as "strippings."—*Editor.*

amount of material, showed that the best milk is always obtained in October, November, and December. This seems to depend less on the conditions of food than that about this time most cows are approaching the end of their period of lactation.

The milk is affected in a quite irregular manner if the rut appears in the cows in the course of the period of lactation ; sometimes the milk remains unaffected, sometimes it becomes scanty but rather richer. Occasionally it curdles on boiling even when fresh ; at other times it is unchanged in quantity but thin and poor.

7. The milk is greatly affected if the cows are taken ill; intestinal disturbances act like defective nutriment. According to Fleischmann the specific gravity in simple indigestion may often fall to 27° or 29°. What can be said on the special abnormities of freshly drawn milk within the narrow limits of this book has already been given.

APPENDIX TO SECTION B.

THE MOST FREQUENT SOPHISTICATIONS OF MILK.

§ 291. The favourite sophistications of milk consist, on the one hand, in the more or less complete removal of the cream and the other on the addition of water. Adulterators frequently apply both these methods simultaneously, from the following reasons :—

If milk is deprived of a large part of its lightest constituent, the fat (specific gravity at 15° 0·93), it becomes specifically heavier, and a simple determination of its specific gravity reveals the fraud. But if to a milk which in spite of its fat is still heavier than water, on account of its dissolved salts, sugar, and albumenoids (1·029 to 1·033), we add water, its specific gravity will fall below the normal limits and thus betray the sophistication. It is evident that simultaneous skimming and watering, if carried on under the guidance of the lactometer, may produce a milk of the same specific gravity as the new milk.

Experienced milk sophisticators add to the new milk, whether pure or watered, so much skim milk that its specific gravity exactly comes up to the limit fixed by authority, or they mix the skimmed milk with the smallest quantity of

new milk, which brings it to the prescribed weight of half-milk.

In comparison with these methods of sophistication all others fall far into the background. It is beyond doubt that the additions again and again mentioned in books—chalk, milk of lime, gum, emulsion of oil of almonds, cane-sugar, starch, or even calves' brains stirred up (!)—have, in recent days at least, been very rarely observed. I shall therefore not give any particulars as to their (usually for the most part easy) detection. On the addition of starch, see § 270; for gum, see § 215; for cane-sugar, consult § 220. Moreover, 1 per cent. of cane-sugar betrays itself by the taste. Concerning soda and preservative agents see § 283. On one occasion ultramarine was found to the extent of 82 *mgrm.* per litre.

A refined fraud has been several times detected in France. There is added to new milk a quantity of heated skim-milk which has recovered by heating the opacity which it had lost by skimming. A chemical examination easily discovers the removal of the fat, but optical methods fail completely.

C. Decision on Milk.

§ 292. As milk is consumed very extensively without previous boiling, the following pages treat always of decisions on unboiled milk. If by boiling a number of the grounds enumerated for objection are obviated, they must still be taken into account in the decision, since milk is universally sold unboiled. The bulk of the public are not convinced of the necessity of boiling, and no one can judge by the mere appearance of milk whether it must be boiled, nor whether it has been boiled or not. The chief questions which we are to answer are the following:—

1. Does the milk in question contain the proportion of nutrient substances which we should expect, and if not, why not?
   a. Because the cows are in a condition unfit for producing milk?

b. Because the milk has been subjected to fraudulent manipulations?

2. Is the milk fresh, endowed with all the attributes of an article of consumption, *i.e.*, of agreeable taste and normal appearance, &c., or is it unappetising, unclean, entering into decomposition, or already decomposed?
3. Is the milk free from hurtful substances, and from foreign substances altogether?
   a. From chemical poisons?
      1. From the cow.
      2. Introduced through secondary channels.
   b. From other additions (water, preservative agents, starch, &c.)?
   c. From all exciters of infection?
      1. Derived from the cow.
      2. Introduced secondarily, that is, by contact with impure hands and utensils, by the addition of water, or by standing in sick-rooms or infected stalls.

As soon as one of these points is answered unfavourably for the vendor the hygienist must object to the milk, whether the cows are diseased or badly fed, or whether intentional sophistication has taken place.

1. Decision on Milk as regards its Nutritive Value.

§ 293. If milk in its proportion of fat and solids falls below the minimum which is demanded by[1] local regulation for the district in question, it must be pronounced of inferior quality. In most parts of Germany from 2½ to 3 per cent. would be an easily fulfilled demand made upon new milk. The project for an imperial ordinance on milk-control proposed to accept 2½ per cent. of fat, which in South Germany at least would permit of a very extensive removal of cream; Berlin required 2·7 per cent. of fat; Paris, 3·5 per cent.; New York, 3 per cent.; London, 3 per cent.

[1] This value is to be ascertained by stall-trials.

A milk of inferior nutritive value must be condemned by the physician from the point of view of the physiology of nutrition as a scarcely suitable food for invalids and children; its use may, *e.g.*, render the success of milk-cures questionable.

If the courts of justice have to decide whether a milk of low value is inferior with or without the fault of the vendor, the hygienist has to raise the question *whether the milk, in addition to its inferior value, may not possess other suspicious attributes.* For this purpose an examination of the cause of the inferiority becomes necessary.

2. Decision as to the Addition of Water and the Removal of Cream.

§ 294. If we have to do with the milk of the dairymen, a mixture of very many samples, a certain decision on the addition of water and the abstraction of cream may be easily arrived at, since mixed milk must always correspond with the average milk of the district.

If we have the collective milk of a small dairy farmer (three or four cows), our opinion must here be less certain, since in fact several cows may simultaneously yield abnormally bad milk; the decision is quite uncertain when, according to the declaration of the vendor, the question is about the milk of a single cow.

In the two latter cases an absolutely certain decision can be arrived at merely by the so-called stall-trial. As soon as practicable (one or at most three days after the milk has been objected to) the cow or cows must be thoroughly milked into empty vessels, at the same hour as the last milking, under official control. The milking must be performed by an experienced hand—by a stranger, if it is officially demanded. The milk must then be very well stirred for taking the sample.

If the milk is found identical on each occasion, the vendor or producer incurs no penalty; but hygiene demands that even in this case milk of decidedly inferior value should be

excluded from sale, or that it should at least be made publicly known that at present the cows of A. B. are yielding milk of inferior value. When the producer, as shown by a new investigation, is again able (whether by improved diet or by decreased exertion [1]) to supply milk of normal quality, the fact is again made known. Such means would rapidly lead to an improvement in the quality of milk, as they have already done, *e.g.*, in Brunswick.

§ 295. In many cases, certainly after the analysis has shown suspicious numerical values in a milk, the stall-trial will not exonerate the producer, but will lead more assuredly to the penalty as it reveals the fraud. It is then in such cases demanded that the expert should give a decision as to what has been done to the milk, whether merely removal of cream, merely addition of water, or both. If a stall-trial has been made, these questions may be exactly answered; but if such a trial is wanting, from whatever reason, the average composition of the milk of the district is taken as a basis.

It must be here conceded that recently single investigators, at least for certain beasts, after a series of careful experiments, allege a strongly fluctuating composition of milk from day to day, notwithstanding the most uniform feeding, and the observance of all precautions. Compare Macfarlane, *Deutsch. Molkerei Zeitung*, 1891, p. 5, and *Viertelg. f. Fortsch. d. Chemie der Nahrungs- und Genussmittel*, 1891, p. 17. If these results appear more frequently, the entire significance of the stall-trial will be brought into question.

Numerous formulæ have already been drawn up for calculating the remaining constants of milk from the specific gravity and the percentage of fat—the two values most easily determined. Among these formulæ the recent ones of Fleischmann (*Dammer's Lexikon der Verfälschungen*, article "*Milch*," by Fleischmann), deserve the greatest attention.

He puts

s = specific gravity of the milk.

d = degrees of the lactodensimeter, *i.e.*, specific gravity of the milk minus the specific gravity of water.

[1] It need scarcely be said that in England milch-cows are not employed as beasts of burden.—*Editor.*

f = fat in per cents. by weight.
t = total solids in per cents. by weight.
r = total solids minus fat = $(t-f)$ in per cents. by weight.
m = specific gravity of total solids.

We have then the following relations, which enable us to calculate t from f and s:—

(1.) $t = 1{\cdot}2f + 2{\cdot}665\,\frac{100s-100}{s}$

(2.) $f = 0{\cdot}833\,t - 2{\cdot}22\,.\,\frac{100s-100}{s}$

(3.) $m = \frac{t}{t-100\,\frac{s-100}{s}}$

We will now draw conclusions from the values obtained for s, f, t, and m.

1. If s, f, and t are uniformly diminished as compared with the stall-trial or the average, so that r also becomes small, a corresponding addition of water has taken place. In this case m has remained unchanged, and gives a value approximating to 1·3 or 1·4.

2. If f alone is remarkably low, t less reduced, s increased, and r normal, cream has been abstracted. Its amount is found by comparison with the percentage of fat in the milk from the stall-trial. In this case m will be raised decidedly above 1·3 or 1·4, since the light fat has been removed from the solids, thus increasing their specific gravity.

3. If f is remarkably low, t and r reduced, but s tolerably normal, we have combined falsification of adding water and abstracting cream.

In order to obtain more exact values as to the degree of watering, of removing cream, or of combined falsification, we have from Recknagel (*Sechste Versamml. der fr. ver. bayer Chem.*, Munich, 1887) formulæ[1] in which

all letters marked with 1 refer to stall-trial milk,
all marked with 2 refer to the sample in question.

In addition to the above signs, there occur also the following:—

w = *cc.* of water which have been artificially added in 100 *grm.* of the sophisticated milk.
v = *cc.* of water which have been artificially added to 100 *grm.* of the sophisticated milk.
ϕ = *grm.* fat which have been removed from 100 *grm.* of milk.

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[1] F. J. Herz has constructed from the above formulæ of Fleischmann and those of Recknagel a table which, without calculation, enables us to read off from the specific gravity and the proportion of fat—

1. Total solids.
2. Quantity of water added per litre.
3. Quantity of fat per litre removed.

The formulæ in their simplest form run :—

$$w = 2{\cdot}8\,(d_1 - d_2) + 3\,(f_1 - f_2)$$

$$v = \frac{100 + w}{100} \times w$$

$$\phi = \frac{100\,(f_1 - f_2) - f_1\,w}{100 - w - f_2}$$

The following four examples will show how the formula acts :—

(1.)

Stall Trial.		*Milk in Question.*	
d_1	f_1	d_2	f_2
31·8	3·47	28·5	3·09

whence $w = 2{\cdot}8\,(31{\cdot}8 - 28{\cdot}5) + 3\,(3{\cdot}47 - 3{\cdot}09)$,

$w = 2{\cdot}8 \times 3{\cdot}3 + 3 \times 0{\cdot}38$,

$w = 10{\cdot}38$ per cent.

$$v = \frac{100 + 10{\cdot}38}{100} \times 10{\cdot}38 = 11{\cdot}4 \text{ per cent.}$$

$$\phi = \frac{100\,(3{\cdot}47 - 3{\cdot}09) - 3{\cdot}47 \times 10{\cdot}38}{100 - 10{\cdot}38 - 3{\cdot}09}$$

$$\phi = \frac{38 - 36}{86{\cdot}53} = 0{\cdot}02,$$

i.e., no fat has been removed, but about 10 per cent. of water has been added.

(2.)

Stall Trial.		*Milk in Question.*	
d_1	f_1	d_2	f_2
31·2	4·19	24·6	3·37

$w = 2{\cdot}8\,(31{\cdot}2 - 24{\cdot}6) + 3\,(4{\cdot}19 - 3{\cdot}37)$,

$w = 20{\cdot}9$ per cent.

$$v = \frac{100 + 20{\cdot}9}{100} \times 20{\cdot}9 = 25{\cdot}3 \text{ per cent.}$$

$$\phi = \frac{100\,(4{\cdot}19 - 3{\cdot}37) - 4{\cdot}19 \times 20{\cdot}9}{100 - 20{\cdot}9 - 3{\cdot}37}$$

$\phi = -0{\cdot}05$,

i.e., whilst the milk contains in 100 parts 21 parts of added water (or 100 parts of the original milk have been diluted to 125 parts), the milk has not been deprived of cream, as ϕ is approximately = 0. That the minimum surplus of fat of 0·05 is to be explained by small errors of observation or by the manner of sampling requires no demonstration.

(3.)

Stall Trial.			*Milk in Question.*	
d_1	f_1		d_2	f_2
29·60	4·20		31·8	2·10

$w = 0{\cdot}14$ $\quad v = 0{\cdot}14$ $\quad (\phi = 2{\cdot}18)$,

i.e., the milk has not been watered, but 2·18 *grm.* have been removed from 100 *grm.*, or about 50 per cent. of the fat.

(4.)

Stall Trial.			*Milk in Question.*	
d_1	f_1		d_2	f_2
34·0	4·04		32·5	2·86

therefore $w = 7{\cdot}7$ $\quad v = 8{\cdot}0$ $\quad \phi = 1{\cdot}0$.

We have here a combined sophistication; the milk has been first partially skimmed, and then from 7 to 8 per cent. of water has been added. The specific gravity would here have shown nothing suspicious; indeed, in many districts where the cattle give poor milk, a sample with $d = 32{\cdot}5$ and $f = 2{\cdot}86$ would be scarcely objected to.

§ 296. The attitude assumed by hygiene in reference to skimming and watering is perfectly definite (even if we disregard the above-mentioned decrease in value).

1. A removal of cream by centrifugalising adds no further disadvantages to the reduction of value, as the creaming is effected rapidly (half an hour), and the milk remains fresh.

2. Milk deprived of cream by standing in the ordinary manner (twelve to forty-eight hours at 10° to 15°) is to be judged according to § 332, and according to § 297 is no longer to be considered fresh milk. Whoever buys new milk has, according to a tacit supposition, a right to entire milk.

3. Watering involves the risk—especially if well-water is used from wells communicating with cesspools—that organisms pathogenous for man may pass into the milk, and may multiply largely therein, especially if it is improperly preserved. It cannot be denied that water must be used for rinsing out the pails, but milk-cans which are rinsed with water containing the bacilli of typhoid fever, and are dried in an invert position, will introduce into the milk far fewer typhoid bacilli capable of development than if only 5 per cent. of water were directly added. In Holland, incomprehensibly enough, watered milk may be sold if it is only duly declared.

3. Freshness and Relishing Quality of Milk.

§ 297. As soon as milk is in such a state that it is consumed by man without relish, or with repugnance—even if raw—it must be objected to, although no proof can be submitted that it is injurious. So long as there is no place provided for the sale of boiled milk, not hurtful but inferior in value—as there is in some towns for meat—this is the only point of view from which it can hygienically be regarded.

1. Any milk which has passed the incubation stage of the

formation of acid, *i.e.*, which requires for 100 *cc.* more than 10 *cc.* of one-fourth normal soda-lye, may be suspected as on the point of turning sour, and must on no account be pronounced fresh milk. It is not yet exactly unrelishing, but it is no food for children and invalids, *i.e.*, it is no longer milk of the first quality.[1] As cleanly milk at 15° does not vary in its degree of acidity in thirty-six hours, such milk is either abnormally dirty or mixed with stale residues of milk, abnormally warm (not cooled, conveyed on summer days), or it has been kept for an unusually long time. Milk which requires per 100 *cc.* from 11 to 11·2 *cc.* of one-fourth normal soda-lye coagulates on boiling.

2. Any milk in which there may be detected the admixture of any solid whatever (flocks, clots, &c.), which on standing for two hours in a measuring-cylinder deposits a sediment (cow-dung, sandy particles), possesses a changed appearance, or which only on boiling coagulates in flocks or altogether, is undoubtedly repugnant, and often injurious to health.

Flocks occur in colostrum; it occasions diarrhœa in children, and has an unpleasant taste, on account of its low proportion of sugar. Its sale is generally prohibited until about eight days after the birth.

In inflammation of the udder (mastitis) the milk is flocculent, generally containing blood and pus, and it may unconditionally become dangerous (Vaughan, *Arch. f. Hygiene*, vii.).

The slimy milk, forming long threads, as it seems in many diseases of the udder to be directly emitted, and which in other cases only arises outside the cow, is harmless, but *per se* repugnant. In Holland, however, milk is intentionally made slimy by adding portions of milk containing the micrococcus of the long "*wei*;" in northern countries something similar is effected by the addition of Pinguicula.

Milk seems never to be obtained free from small fragments of excrement, whence it is always strained before being sold to the public. If this is omitted, it must be pronounced insufficiently clean.

Renk is unwilling to sanction any sediment. According to our experience in Würzburg, milk containing not more than 2 *mgrm.* dirt

[1] In many places "sour milk" is prepared for sale as a refreshing article of food and consumption. Here, of course, acidity, high number of microbia (§ 285), and coagulation are not defects, but necessary properties. Of course only the new milk of healthy cows should be set to turn sour, and that in clean rooms and vessels. If a down of *Oidium lactis* is developed on the surface, the milk is not appetising.

per litre may be regarded as sufficiently clean (see § 286). On the contrary, many wholesale dairies demand from the producer unstrained milk, in order to judge of the degree of cleanliness in the production.

3. All milk which deviates decidedly in colour from the normal quality (it takes a pale yellow tint when the cows are turned out to graze) is to be rejected as offensive and occasionally injurious to health.

The presence of pus renders milk yellowish, highly repulsive, and dangerous to health. In "yellow galt," an infectious inflammation of the udder observed in Switzerland, and occasioned by streptococci, the milk is deep yellow, flocculent, and quite irregular in composition. Bloody milk may be occasioned by rough milking, the ingestion of turpentine, and, it is alleged, by the consumption of much fresh clover. In jaundice the yellow bile-pigment finds its way into the milk.

Blue, yellow, or red milk proves prolonged, unclean, warm housing. Blue milk caused by *Bacillus cyanogenus seu syncyanus* is harmless according to Neelsen, Hüppe, and Haubner, but hurtful according to Mosler and Uffelmann. Mosler's observations refer to cows suffering from gastritis: a mother with her two children, after taking such milk, were attacked with febrile enteritis with prostration—the *Bacillus cyanogenus* was certainly innocent of the mischief (*Virch. Arch.* vol. 43). Concerning the harmfulness of yellow and red milk there exists no evidence. Abnormally watery milk, as yielded by many diseased cows, often attracts attention by its blueish colour.

A series of plants are said to colour milk, *e.g.*, yellow or reddish—carrots, madder, rhubarb, species of bed-straw; blue—alkanet, mercurialis, melampyrum, species of polygonum, &c. Further experiments are here desirable.

Such colours, if they occur, may often be difficult to interpret. From a hygienic point of view they appear scarcely dangerous, but always unpleasant.

4. Any milk of an abnormal taste and smell is always inferior in value, but mostly disgusting, and sometimes even dangerous to health.

Milk tastes disagreeably rancid, bitter, &c., immediately after milking, if half-decayed fodder has been consumed, or rancid oil-cake, cocoa-nut cake, spoiled beets and potatoes, sour brewers' grains. But certain plants, even if eaten fresh, give the milk a bad taste, *e.g.*, beet leaves and heads, various Compositæ (*e.g.*, wormwood, &c.), too much pea- or bean-straw. Milk of a bad taste is often injurious, especially after the consumption of spoiled, rancid, or fermenting fodder, producing intestinal catarrh. Milk previously good often readily takes a sour, bitter, irritating taste in consequence of the action of schizomycetes (§ 285). The milk may also be rendered bitter by schizo-

mycetes whilst in the udder. If the bitter taste can be traced to schizomycetes, the milk is highly suspicious as regards its injurious action on health.

Cows which have recovered from inflammation of the udder often yield milk of a salty taste. In general, however, the milk is salty only from one or from some of the teats, or only the first part of the milk drawn from one teat is affected. The taste of the milk is often more saline than if 5 *grm.* of common salt had been added per litre. The proportion of ash is often raised twofold (Engling). I am not aware whether such milk is injurious.

New milk has often an abnormal odour if the cows have been browsing on a variety of strongly-smelling plants—garlic, carraway, fennel —or if they have been taking strong-scented medicines, *e.g.*, camphor, oil of turpentine, &c.

If milk is allowed to remain in strongly-smelling places it may absorb mouldy smells, or also the smell of carbolic acid, &c.

For a full discussion of the most important faults of milk, chemical and bacteriological, a subject far from having been as yet satisfactorily investigated, see Hess, Schaffner and Bondzynski, *Milchzeitung*, 1891, No. 13.

4. Poisons in Milk.[1]

§ 298. If milk from any source has had a poisonous action, we may presume that milk from the same source will continue to have a poisonous action, and proceed accordingly. But milk is only examined for poisons on very special evidence.

Poisons find their way into milk:

1. From fodder. Occasionally the transit of poisonous substances into milk is said to have been observed from poisonous plants, such as veratrum, belladonna (atropin), colchicum, &c.

   According to Ratti the inhabitants of a district of Rome were taken ill in consequence of consuming the milk of goats

[1] For the detection of these poisons the instructions hold good which have been given in § 251 concerning meat. According to Vaughan tyrotoxicon is detected as follows: The milk, coagulated spontaneously or by the intentional addition of acids, is filtered, the filtrate is rendered slightly alkaline with potassa-lye, and shaken out with ether. The residue left on the evaporation of the ether consists of a little water, from which crystals of tyrotoxicon are deposited possessing an unpleasant smell and taste. Very small quantities given to young cats in milk produce violent vomiting and diarrhœa, and may prove fatal. A critique of the chemical reactions of tyrotoxicon may be found, by H. A. Weber, in *Journ. Am. Chem. Soc.* (1890, p. 485).

which had grazed in meadows abounding in colchicum (*Jahresber. f. Pharmacie*, 1885, p. 487). Feeding on artichokes is also said to have occasioned the production of very dangerous milk (?) *Chemiker Zeitung* (xv. p. 773). Kimmel Findlay in the *Münch. Med. Wochenschrift* (1890, p. 64) describes a disease of cows in Ohio caused by (infected?) grass. The milk may prove fatal to man. (Milk sickness.)

According to Bollinger (*Deutsche Zeit. f. Thiermed.*, vol. vi.) the milk of cows was poisonous which had been fed upon oil-cake containing seeds of castor-oil plant.

Goats' milk has proved rapidly fatal when these animals had fed upon laburnum, which they endure very readily.

2. Small quantities (generally mere traces) of arsenic, lead, copper, antimony, mercury, iodine, aloes, may pass into milk from medicines given to cattle; lead may also be introduced by the use of food coated with plumbiferous dust (near white-lead works).

Poisonings in this manner have not come to my knowledge. The following observation of Harms (*Jahresber. 5 und 6 der hannov. Thierarzneischule*) show that great caution is necessary. A milch-cow received a dose of 45 *grm.* tartar-emetic; 15 litres of her milk were given to five kids and two puppies. Violent diarrhœa occurred in all these animals.

3. Lead, copper, and zinc may be introduced into milk from the vessels in which it is preserved, especially if it has become sour. In Würtemberg the use of zinc and copper utensils is positively prohibited. Tinned iron is in general use, but enamelled pans are preferable.[1] Fleck is of opinion that the absorption of zinc is the very cause why milk keeps well in zinc pails.
4. By the action of schizomycetes. Vaughan regards tyrotoxicon as the cause of summer diarrhœa and cholera infantum. This fact has been demonstrated by a series of severe, in part even deadly poisoning cases in America consequent upon the use of milk, vanilla-ice, &c. In Europe it has not yet been shown with certainty (*Arch. f. Hyg.*, viii., and *Centralblatt f. Bakteriologie*, iii. 591.) Hitherto, moreover, the

[1] There is some inferior enamelled ware in use in England containing lead carbonate, capable of being attacked by sour milk.—*Editor.*

exciting microbe has not been discovered. Milk containing ptomaines may generally be detected by its smell and taste. The European records of cases contain a large number of milk- and cheese- poisonings, which may be not unnaturally referred to tyrotoxicon (*Jansen Hyg. Rundschau*, i. 233).

The symptoms of poisoning with tyrotoxicon are : violent vomiting, diarrhœa with watery dejections, prostration, pains in the limbs, headache, violent thirst. Frequently also abdominal pain, sensation of cold, spasms of the muscles—therefore a type of illness resembling cholera. The recovery is generally slow.

5. Artificial Additions.

§ 299. Every milk containing *any addition whatever* is objectionable. Even though dextrine, gum, starch, &c., are harmless for adults, they are not necessarily so for the tender age of children (*e.g.*, starch); further, only milk of inferior value is furnished with such additions. Concerning preservative agents see § 231. Soda and sodium bicarbonate are utterly objectionable additions (§ 283); they further serve to deceive the public as to the newness and cleanly condition of milk. Proust regards the addition of sodium carbonate as very hurtful to children (*Milchzeitung*, p. 273). Compare Lazarus, *Wirkung der gebräuchlicheren Mittel zur Milchkonservirung* (*Zeit. f. Hygiene*, viii.).

6. Micro-organisms in Milk.

§ 300. According to § 285 all milk met with in trade, if not sterilised, contains microbia, mostly in abundance. The enumerations which are hitherto available do not permit of any practical hygienic application, or at least they scarcely give us a deeper insight than the simpler titrations of the acidity. The determinations of the several kinds of microbia may be more important. Any milk which contains bacteria pathogenic for man is injurious to man; if it contains merely species pathogenic to the lower animals it must at least be characterised as repulsive, keeping it distinctly in view that

our experience of the effects upon man of such milk are as yet very defective. The milk of cattle suffering from acute disease is almost always scanty, poor in nutritive matter, and of a non-appetising appearance. In general, therefore, all milk of diseased animals must be treated as directly pernicious; that is, it must be excluded from human food, and at most used after boiling for the food of beasts. Injuries to health from milk occur most frequently in the following cases:—

In tuberculosis. The bacilli of tubercle are found not merely in the milk of cows which suffer from tuberculosis of the udder, diagnosed by nodose hardening without inflammation (Bang). Hirschberger, in Bollinger's Institute (*Deutsch. Arch. f. Klin. Med.* 1889, p. 500), inoculated guinea-pigs eleven times successfully with the contents of the udders of twenty cows, in which on slaughtering tuberculosis (in some cases only slight) was recognised, though not in the udder. As about 10 per cent. of milch cows are tuberculous the danger to health by the use of the raw milk of *one* cow appears very considerable. By centrifugal treatment the bacilli of tubercle pass along with other bacteria from the milk into the cream though the milk remains infectious. (Bang, *Deutsche Zeitschrift f. Thiermed.*, xvii. 1).

Fortunately mixed milk, as purchased, is generally harmless; ten samples of mixed trade-milk purchased at Munich were all harmless. Natural milk containing the bacilli, if diluted forty, fifty, or a hundred times, is found to have become harmless (Gebhard, in Bollinger's Institute).

In foot and mouth disease. After the consumption of unboiled milk children are often attacked with aphthæ and intestinal catarrh, and calves still more frequently. The exciter of the infection is quite unknown. Heating to 60° does not destroy the virulence which is only put an end to by ebullition (Dieckerhoff).

In cases of suppuration on or in the milk-glands staphylococci and possibly streptococci become mixed with the milk. In cases also of artificial infection with *Staphylococcus pyogenes aureus* its transit into the milk has been observed. The ingestion of milk with which cultures of staphylococcus had been mixed, proved fatal to young rabbits in about one-fourth of the cases. Karlinski (*Centralblatt f. Bakteriologie*, vi. and viii. 375) and Eiselsberg (*Berlin Klin. Wochenschrift*, 1891, No. 23).

In *Mastitis contagiosa* Nocard and Mollereau isolated a streptococcus which, if injected into the glands of healthy animals, rendered them ill. The sour, slimy milk was indeed harmless for animals fed with it, which, however, does not prove its harmlessness to man. Kitt's studies on mastitis and the accompanying changes in the milk have made known a pathogenic bacterium (*Deutsch. Zeit. f. Thier. Medecin*,

xii.). Kitt, however, does not regard the unitary character of the process as probable.

In splenic fever the transition of the bacilli into the milk has already been observed. The milk of cattle suffering from rabies does not contain the poison of that disease, as Pasteur and Zagari have shown experimentally (*Centralblatt f. Bakteriologie*, iii. 409). With this practical experience agrees; the harmfulness of such milk has never been observed, but often its harmlessness.

In cattle-plague and charbon symptomatique milk has never been found injurious, but it is exceedingly disgusting.

In sepsis (putrescent inflammation of the uterus) the milk is extremely suspicious and probably not seldom poisonous.

§ 301. It must never be forgotten that microbia can be introduced into milk not merely from the udders of diseased cattle, but may be transferred by particles of dung, fragments of straw, &c., *e.g.*, with bacilli of splenic fever, of *Oidium albicans*, and of *Bacillus coli communis*.

R. Demme isolated from milk insufficiently boiled, which had acted pathogenically or toxically upon infants, a species of saccharomyces (*S. ruber*), evidently closely allied to the "red yeast" of laboratories. Puppies fed with milk-cultures of this microbe became ill (*Centralblatt f. Bakteriologie*, ix. 270). This micro-organism is certainly derived not from the cow but from the surroundings.

It has been repeatedly remarked that at a suitable temperature the majority of pathogenic bacteria multiply luxuriantly. This is especially the case with the exciters of typhus, cholera, pneumonia, diphtheria, glanders, and with species producing septic and suppurative processes. Such proof is wanting for the bacilli of tubercle. We cannot here examine whether numerous epidemics of typhus, scarlatina, diphtheria, &c., of late years can be rightly referred to the use of milk. See references concerning such epidemics in Uffelmann's *Jahresberichte über die Fortschritte der Hygiene*. To my knowledge the presence of the bacilli of typhus or diphtheria in milk has not been demonstrated in such epidemics. See E. Roth (*Milchtyphus Vierteljahrschrift f. oeff. Gesundheitspflege*, 1890, xxii. part ii.) and Almquist (*Zeit. f. Hygiene*, viii.). However imperfect the proof of a connection between the use of milk and the attack of illness has been, in many cases the

possibility or rather the probability of an infection by means of milk remains unconditional, for all cases the exciting organisms of which retain their vitality in milk.

In such considerations it must be remembered that non-sterilised milk affords a far worse nutrient medium than sterilised, and that the acid formed attacks the pathogenic microbia in a shorter time.

According to L. Heim (*Arbeit. d. Kais. Gesundh.*, vol. v.), the exciters of the following diseases remain capable of development in the most favourable cases in days :—

	Cholera.	Typhus.	Tuberculosis.
In milk . . .	6	35	10
In butter . . .	32	21	30
In curd . . .	0	1	2
In whey . . .	2	1	14
In cheese . .	1	3	14

Milk coagulated with rennet is regarded as cheese. Sterilisation was intentionally avoided, no enumeration was attempted, the presence of the microbia being merely established. On one occasion Heim observed a longer continuance of life in warm milk than in cold. Hesse observed that on one occasion the bacilli of typhus remained alive for four months. Gasperini (*Centralblatt f. Bakteriologie*, vii. 641) found the bacilli of tubercle remaining alive in butter for 68 and 120 days. Lower values were found for butter by Laser (*Zeit. f. Hygiene*, x.). Typhus bacilli remained alive in butter from five to seven days, cholera bacilli for five, and the bacilli of tubercle for less than twelve days.

Concerning scarlatina and the other acute exanthemata a decision is attainable only by means of epidemiological studies, as their exciting organisms are unknown. All the positive statements, especially of English investigators, on the microbe of scarlatina are hitherto inaccurate. A so-called epidemic of scarlet fever in cows was found to be cow-pox (Crookshank, *Centralblatt f. Bakteriologie*, iii. 331). In other cases eruptions on the teats came into question. Klein's micrococcus of scarlatina cannot be distinguished from *Streptococcus pyogenes*.

7. Decision on Milk for Infants.

§ 302. There has been recently a universal effort in cities to procure an especially rich milk for infants. It is the duty

of hygiene when an opinion is required on such milk, or on an entire dairy, to see above all things—

1. Whether the cattle kept are of races which give rich milk (§ 290).

2. Whether healthy cattle are kept, especially if any cows suffering from tuberculosis or foot-and-mouth disease are used to supply milk. Consequently a permanent veterinary control is essential, or, as Schmidt-Mülheim proposed, an examination of milk for tubercle-bacilli (by inoculating guinea-pigs) is made monthly or every two months.

Plaut has recently observed that the acidity of the quite fresh milk of diseased cows is almost invariably abnormally low. He proposes to include a titration of acidity in the preliminary examination of the health of cows.

3. Whether the cattle are rationally fed. Hitherto dry food, *i.e.*, good hay—not mouldy or scorched—and grain, were considered as the ideal; latterly green food from good meadows is regarded as perfectly suitable. All the inferior foods mentioned in § 390 must be absolutely excluded from use.

4. Whether the cattle, the stall, the appliances and milkers are carefully cleanly.

5. Whether every occasion is carefully avoided which might render milk obtained in good condition subsequently hurtful. Milk must therefore be rapidly cooled, not preserved in vessels of lead, zinc, or copper, or in unclean wooden pails, nor allowed to remain in close, mouldy rooms, &c. Dwelling-rooms and especially sick-rooms are absolutely unfit for keeping milk. In domestic epidemics in the milk-business, *e.g.*, on the outbreak of scarlatina, diphtheria, typhus, cholera, &c., the sale of milk must at once cease.

6. Whether preservative agents are excluded (see § 235).

In any case it must only be given to children when boiled.

The demands just made for the production and the sale of milk for children, invalids, and convalescents hold good naturally as the ideal for the total production of milk.

APPENDIX I.—PRESERVED MILK.[1]

§ 303. We distinguish:—

1. Milk evaporated to the consistence of a syrup.
   a. Sweetened milk to which an eighth of its volume of cane-sugar has been added, and which is then evaporated down in a vacuum apparatus to a third of its volume, and is then rapidly cooled and at once soldered up in tins.
   b. Unsweetened evaporated milk. Formerly such preparations did not keep well, but now, *e.g.*, Loefflund obtains a product which keeps for an indefinite time, and is known as "Allgäu Cream-Milk." It is evaporated down to from one-third to one-fourth of its volume, and is then heated to above 100° after being soldered up.

      Tins containing 330 *grm.* with 37 per cent. of solids, yield, if made up to 1 litre, an excellent unsweetened milk. The contents of the tins will keep indefinitely, being really sterilised. According to Soxhlet it is important to free the milk by centrifugal action from the "milk-slime" (a little albumen and potassium phosphate) which is enclosed in all the coarser impurities, not separable by the finest sieve.
2. *Preserved Milk.*—Milk enclosed in tins, not concentrated and not sweetened, but sterilised by over-heating. Without great importance as being too bulky.
3. So called milk-powder. Milk evaporated to the state of a powder and retaining only 5 per cent. of water. Dissolves in hot water to a liquid resembling milk.

Even the best useful preparations, *e.g.*, from Drenkhan in Holstein, do not yield a product exactly like milk; the solution

[1] For complete analyses see Table IX.

is somewhat imperfect, and a slight accompanying taste of milk which has been boiled for a long time is unmistakable.

The examination for determining the nutritive value in all these cases is to be conducted according to Section IV., and to the rules specially given for milk. Further, all the tests must be undertaken which are practised for preserved foods (animal and vegetable) (§ 265). The decision upon their value as nutriment for adults on the basis of these examinations presents no difficulties. For the nutrition of infants the high proportion of cane-sugar in many preparations is very disturbing. See Uffelmann and Munk, *Handbuch der Diätetik*, p. 306.

Very recently "sterilised milk for children" is prepared industrially in many towns. What we understand under milk for children has been said above; in testing the sterility by means of plate-cultures the following must be considered. If the milk was sterile it is possible that micro-organisms may have subsequently entered owing to bad soldering. The examination should therefore be made not only on freshly-sterilised milk, but on such as has been kept for about a week. The keeping should be twofold; some bottles are kept in the incubation-niche, which only really sterile milk can bear without evincing decomposition; other bottles are allowed to stand at the temperature of a dwelling-room, and are thus tested for their durability under the conditions of practice. In all cases we should wait for eight days before enumerating the plates which have been made up, since microbia which have not been killed may be so enfeebled that their development is much retarded.

According to the researches of Freudenreich (*Annal. de Microgr.*, 1888, No. 1) an absolute sterilisation of milk—destruction not merely of cocci and bacilli,[1] but of the resistant spores of the latter—is at present not practicable without

[1] According to the researches of Van Geuns (*Arch. f. Hygiene*, ix.) the most important pathogenic species, when free from spores, are killed in one minute by a temperature of 60°, though splenic fever and malignant œdema require 80° or 78°. See also H. Bitter, *Versuche über das Pasteurisiren der Milch. Zeit. f. Hygiene*, viii.

prolonged heating to 100° and upwards, and thus producing an irritating taste and a brownish colour, owing to a partial formation of caramel. For the present, therefore, we must be content to require of "sterilised" milk that if kept in a cool cellar for eight days not the slightest decomposition can be detected either by the senses or by acidimetry, but we must lay down the postulate that a method for the absolute sterilisation of milk on an industrial scale should be sought for.[1]

Concerning the difficulties of a perfect sterilisation of milk by the appliances of the laboratory and the household, compare the diligent investigation of E. Strub (*Centralblatt f. Bakteriologie*, vii., Nos. 21 and 23, as also H. Bitter, *Versuche über das Pasteurisiren der Milch. Zeitschrift f. Hygiene*, viii.).

APPENDIX II.—CREAM.

§ 304. Cream is partly obtained by allowing milk to stand for some time at rest in cool rooms and skimming off the upper layer, or it is rapidly separated by means of centrifugal apparatus.

The product brought to market as cream varies exceedingly in its composition. For instance, Sendtner found at Munich the following fluctuations in the price and composition of cream:—

Price per Litre. s.	Total Solids.		Fat.		
	Min. Per Cent.	Max. Per Cent.	Min. Per Cent.	Max. Per Cent.	Mean. Per Cent.
$\frac{4}{10}$	13·3	20.18	4·85	11·59	11·5
$\frac{6}{10}$	13·3	24·7	4·88	16·60	10·2
$\frac{8}{10}$	16·6	23·7	8·5	16·6	12·6

One litre whipped cream at 1s. contained 8·7 per cent. and 10·5 per cent.; 1 litre at $1\frac{2}{10}$s. contained 13·5 per cent.; 1 litre at 2s. 15·0, 34·4, and 52·5 per cent. of fat.

[1] Even the most recent process of Neuhaus, Gronwald, and Oehlmann of Berlin yields, according to Petri and Maassen (*Arbeit. aus d. Kaiserl. Gesundheit. Amt.*, vii.), no sterile milk if resistent spores are present. The milk will doubtless keep for weeks and months at the temperature of a dwelling room, but often spoils in the incubation-niche.

Hence an accurate definition of cream is impossible; its nutritive and commercial value is about in proportion to the percentage of fat. Cream readily turns sour, but in this state also it forms a special food.

The acidity may be determined as for milk (§ 282); for three separate specimens of "sweet cream" I consumed respectively per 100 *grm.* 10·0, 10·0, and 11·2 *cc.* of one-fourth normal soda-lye, *i.e.*, values similar to those of milk not quite fresh. Two samples of "sour cream" required per 100 *grm.* 33·0 and 41·6 *cc.* of one-fourth normal soda-lye, which agrees with sour milk (see § 286 and § 297).

The special hygienic requirements made upon sweet and sour cream do not differ from those made from sweet and sour milk (see § 297).

Koumiss and Kefir[1] are articles of food and consumption hitherto too little used to require discussion here. For details see Herz, also Theodoroff, "*Hist. u. exp. Studien über den Kefir.* Würzburg, 1886. Biel, *Chem. Zeit.*, 1885, p. 783.

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[1] Koumiss is obtained by the fermentation of mare's milk. Kefyr or kefir is prepared from cow's milk by a special fermentation.

Unfortunately the valuable researches of Soxhlet and his pupils have been in part not published at all, and in part they have appeared scattered in agricultural literature which is not easily accessible.

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Numerous further researches on the behaviour of bacteria in milk, and the decompositions thereby occasioned, are scattered in the journals. The references in the *Centralblatt f. Bakterologie* afford a quick summary view of the matter.

(*c.*) Periodicals relating especially to Milk and the Milk-Trade.

Milchzeitung. The organ for cattle-keeping in general and the dairy business. Published by Petersen since 1871. Treats both of theoretical and practical improvements, gives numerous original articles and extracts on the bacteriological examination of milk. Accompanied as a scientific supplement by *Forschungen auf dem Gebiete der Viehhaltung und ihrer Erzeugnisse. Jahrbücher für Landwirthschaft.*

Molkereizeitung. Communications from the Laboratory of the Aylesbury Dairy Company, of London. Edited by P. Vieth.

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SECTION IX.

BUTTER AND CHEESE.

1. BUTTER.

§ 305. Butter is a fat obtained from the milk of cows by mechanical manipulations, and used for human food partly unsalted and partly salted.

Whilst the other animal and vegetable fats and oils consist almost solely of the glycerine-compounds (glycerides) of palmitic, stearic, and oleic acids, butter contains also the glycerides of lower, somewhat volatile fatty acids, chiefly butyric acid (but also capronic, caprylic, and caprinic acid). Spallanzani gives recently as the average composition of butter-fat 5·1 per cent. butyrin, 1·0 per cent. capronin, 0·3 per cent. caprylin and caprinin, and 93·6 per cent. of glycerides of fixed fatty acids. The preparation of butter from milk renders it necessary that casein, water, milk-sugar, and salts are present in the best butter. In salt butter this "non-fat" is increased by the common salt used.

After the butter has been melted all the "non-fat" collects at the bottom of the vessel. The butter-fat, when it has been decanted off clear, is no longer known as butter, but is called butter-melt.[1]

The most important tasks of a hygienic examination of butter are to determine—

1. Whether the permissible proportion of the ordinary impurities of butter ("non-fat") has not been exceeded —determination of fat.
2. Whether no foreign (cheaper) fats have been incorpo-

[1] This method of preparing butter is very rarely used in Britain, and the German names given in the text have consequently no English equivalents, save the word "ghee," of Indian origin.—*Editor.*

rated with the butter—determination of volatile fatty acids and of the specific gravity.

3. Whether the butter has undergone no additions of alien colouring-matters or preservative agents.
4. Whether the butter is fresh or already in the course of decomposition (rancid).

In taking samples of butter it must be kept in mind that often a piece of old or falsified butter is coated outwardly with a layer of fresh, pure butter to deceive the buyer. Such butter generally betrays itself on cutting the lumps by the difference of colours and the appearance of strata at the section. Melted butter which has not been stirred whilst congealing has a different composition in the parts at the margin of the vessel which were first solidified, and the portion at the centre which congealed latest. It may even occur that a portion remains liquid (butter-oil). If possible, therefore, the bulk should be thoroughly mixed before sampling, or small portions should be taken from different parts of the mass and mixed together. The outside of large lumps of butter is often paler in colour than the interior owing to the action of light; the outside is generally more rancid than the inside and richer in bacteria.

A. Examination of Butter.

1. Examination with the Senses.

§ 306. Consistence, colour, smell, and taste allow of many conclusions as to the nature of the butter.

Abnormally hard butter is produced by feeding the cows with palm-kernels and linseed-cake. Excessively watery butter is often betrayed on spreading it out by the drops of water which issue; excessive artificial colouring is at once recognised by experienced buyers, and the flavour is an excellent preliminary test for the freshness of butter and for the manner of its preparation and the care employed. But for this purpose the butter should be heated to about 20°, as in cold butter an unpleasant taste is less distinct. It may be at once distinguished whether butter has been made from fresh, sweet cream, *e.g.*, obtained with the centrifugal apparatus (sweet-cream butter), or if it is a preparation from sour cream[1] which has been slowly separated and kept for a long time.

[1] Sour butter is a bye-product of the manufacture of fat cheese. From the cheese milk, which still contains much albumen and fat, these substances are eliminated and churned along with cream. With good management products of a pleasant taste may be obtained, but very bad sorts are sometimes met with in trade.

Further causes for bad flavour are stated to be: feeding the cows with beets, or with spoiled earth-nut (Arachis) and cocoa-nut cake, &c., whilst the best-tasting butter—so-called spring- or May-butter—is obtained when the cows are at pasture, especially on mountain meadows.

2. Determination of Moisture.

§ 307. We evaporate down 5 *grm.* of butter upon 30 to 50 *grm.* of sand previously ignited and weighed as described for milk (§ 274). The loss of weight shows the water.

The attempt to expel the water by heating in a porcelain capsule without addition gives inaccurate results. The water is not readily expelled, and the lower fatty acids are volatilised.

3. Determination of the Proportions of Fat and Non-fat.

§ 308. Five grammes of butter are heated in a porcelain capsule with 20 *grm.* gypsum (see § 277) for six hours to 100°, and frequently stirred with a glass rod. When cold it is extracted with absolute ether (§ 214) until completely exhausted (six to eight hours). The ethereal extract, carefully evaporated in a capacious weighing-glass (§ 214), must be perfectly homogeneous, and must not display any turbidity from drops of water. It must then be kept for an hour at a temperature not exceeding 100°, allowed to cool in the exsiccator, and weighed. On subtracting the percentage of fat as found from 100 the remainder is "non-fat."

A determination of albumen can be made in the residue free from fat according to Kjeldahl's method (§ 212).

4. Determination of Ash.

§ 309. We weigh off about 10 *grm.* butter in a platinum capsule, heating at first very slowly to prevent spirting, and then burn the butter with a small flame. The charcoal is extracted with water, according to § 210. During the final ignition of the ash we must prevent loss from the decrepitation of the sodium chloride by covering the capsule with a plate of platinum.

The sodium chloride is extracted from the ash by means of hot water. The filtrate is made up to 100 *cc.*, carefully and accurately neutralised with dilute nitric acid, and the chlorine is titrated in an aliquot part according to § 175 (or, by preference, determined gravimetrically). The ash dissolved in hot dilute nitric acid may be examined for poisonous heavy metals according to the rules given for domestic utensils. But the heavy metals may be extracted sufficiently for a qualitative recognition without incineration by heating with dilute hydrochloric acid.

If the proportion of sodium chloride is alone to be determined, 10 *grm.* butter are twice shaken up in the parting-funnel, each time with 40 *cc.* of warm water; the watery extract is filtered when cold, made up to 100 *cc.* by washing with water, and then treated as above. Lactose may be extracted for analysis.

5. Determination of Volatile Fatty Acids.

§ 310. From the point of view of the official inspection of foods, it is very important to ascertain whether butter has undergone an addition of foreign fats. Hygiene is also concerned in this determination. There is, indeed, no fear that poisons may insinuate themselves in such adulterations, since there is no poisonous fat available. But in view of the impossibility of the chemical detection of disgusting fats (*e.g.*, those of cattle which have died a natural death), it is important that the addition of foreign fats to butter should be avoided.

Of all the numerous methods which have been devised for controlling the purity of butter-fat, few, unfortunately, have proved trustworthy, hence only the most customary is here mentioned. Numerous procedures, of older date, formerly valued, have been abandoned, and even the one here described is of limited applicability. It depends on the fact that of all the animal and vegetable fats butter contains by far the highest proportion of the lower, readily volatile fatty acids.

The original Reichert-Meissl method has experienced several improvements since its publication in 1879, especially at the hands of Sendtner and Wollny; its execution demands the most scrupulous observance of the instructions in seemingly insignificant details, and experienced chemists always carry out the determination in duplicate, and consider the

mean of the two results as correct. At present the modification given by Wollny (*Milchzeitung*, 1887) is almost universally adopted; in the author's words it runs as follows:—

5 *grm.* of butter melted out, decanted off clear from the sediment and filtered, are weighed into a flask containing 300 *cc.* (round form); length of neck, 7 to 8 *cm.*; width of neck, 2 *cm.*; 2 *cc.* of soda-lye at 50 per cent., which have been preserved and measured with exclusion of carbonic acid and 10 *cc.* of alcohol (96 per cent. by volume) are added, and the mixture is heated with a reflux condenser (§ 214) on a boiling-water bath, occasionally moving the flask. The alcohol is then distilled off from a closed flask, whereby the latter must lie for at least half an hour in a boiling-water bath, and then 100 *cc.* of distilled water are introduced by means of a pipette into the flask, which must then lie for a quarter of an hour longer in the water-bath, protected against the access of carbonic acid, so that the soap is completely dissolved. The clear solution of soap is then at once and whilst at a boiling heat neutralised with 40 *cc.* sulphuric acid, from 30 to 35 *cc.* of which neutralise 2 *cc.* of the soda-lye employed (25 *cc.* monohydrated sulphuric acid to 1 litre of water); two fragments of pumice of the size of a pea are added, and the flask is at once connected to the refrigerator. For this purpose there is used a glass tube 0·7 *cm.* wide, which at 1 *cm.* above the cork is blown out to a ball of 2 to 2·5 *cm.* in diameter, and immediately above the ball is bent obliquely upwards at an obtuse angle, runs on in this direction about 5 *cm.*, and is then bent obliquely downwards at an obtuse angle. It is connected with the refrigerator by means of a caoutchouc tube, not too narrow. When this has taken place the mixture in the flask is heated without boiling until the insoluble fatty acids are melted to a clear transparent mass; then, within half an hour, exactly 110 *cc.* are distilled off into a measuring-flask, the distillate is mixed by shaking, and 100 *cc.* are filtered off into a measuring-flask. From this latter vessel they are poured into a beaker, 1 *cc.* phenolphthaleine solution (0·5 *grm.* to 1 litre alcohol at 50 per cent.) added, and titrated with decinormal baryta-water. When a red coloration appears the contents of the beaker are poured back into the flask, the liquid again decolorised is returned to the beaker and mixed with a few drops until a red colour becomes just visible. (The experiment is to be decided by a single drop.)

From the number of cubic centimetres consumed and multiplied by 1·1, that number must be deducted which has resulted from a blank experiment (without fat), conducted exactly in the same manner, and which must not exceed 0.33.

Explanations.—There are first about from 50 to 80 *grm.* of butter taken from different parts of the sample, melted in a capsule on the water-bath (not over a free flame), and filtered by means of a hot-water funnel. If in the filtrate a watery liquid collects below the hot butter-fat, the supernatant fat is poured clear into another capsule and stirred with a glass rod whilst cooling. Of this we weigh by means of

the same glass rod exactly 5 *grm.* into each of the flasks of prescribed size, previously dried with care, saponify with the alcoholic soda-lye, expel the alcohol exactly as prescribed to frustrate the formation of esters, and exclude the introduction of carbonic acid, as the latter would first be absorbed by the excess of lye, then liberated by the sulphuric acid like the fatty acids, and on titration might require an extra consumption of lye. The pieces of pumice render an equable distillation possible without bumping.

Besides the volatile fatty acids, properly so called, higher fatty acids are carried over into the distillate along with the hot vapours; they float on the surface like eyes, and may be removed by filtration. The longer the distillation is continued the more of these higher fatty acids are carried over.

As the Wollny modification of the Reichert-Meissl process is coming more generally into use both in Germany and abroad, it is advisable to work on this method only, as the results obtained by other processes do not admit of comparison.

6. Determination of the Specific Gravity.

§ 311. This may be effected by means of the Westphal balance exactly as in § 20. The determination is effected either at 35° or 100°. In the latter a peculiar sinking appendage is needed, and the cylinder for the fat is set in a boiling-water bath, closed above, the fumes being conducted away. König has prepared especial aræometers for testing at 100°, the scale of which extends from 0·855 to 0·870.

	Specific Gravity at	
	100° (Sell).	35° (Skalweit).
Butter . . .	0·866–0·868	0·9121
Beef-fat . . .	0·859–0·860	0·9019
Lard . . .	0·860–0·861	...
Margarine . .	0·859–0·860	0·9017

From 10 to 20 per cent. of the three last fats may be detected in butter by the specific gravity with tolerable certainty.

7. Determination of the Melting-point.

§ 312. A glass tube having thin sides is drawn out at one part; the thin part thus produced is bent upwards (*a*), and the tube is connected by means of a small piece of

caoutchouc pipe (*d*) with a thermometer (*c*). At the place where the contraction begins a little of the solid fat, which must have been congealed for at least forty-eight hours and kept in a cold place, is applied to the side of the glass by means of a platinum loop; the thermometer with the small tube is held in a beaker of cold water, which is slowly heated over a small flame, whilst the thermometer is constantly moved. When the fat begins to flow down the side of the glass we note down the "beginning of melting," whilst as the "final point of melting" we take the moment when the turbid drop of fat flowing down becomes perfectly clear.

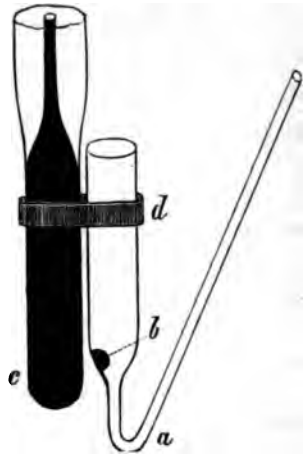

FIG. 103.

In the same manner Bensemann determines the initial and final points of the fusion of fatty acids insoluble in water. For their production 5 *grm.* oil or fat are saponified by boiling with 2 *grm.* caustic potassa in 25 *grm.* alcohol, heated on the water-bath with 250 *grm.* water until the alcohol is completely expelled, when the soap is decomposed by an excess of hydrochloric acid. On further heating the free fatty acids form a clear supernatant stratum, which after congealation is washed upon a well-moistened filter, first with cold, then with ½ litre of boiling water, and dried at from 90° to at most 100° until the weight has become constant. These fatty acids also must have been left for a long time in the cold before they are fit for an exact determination of the melting-point.

As examples of the results of the method I may quote Bensemann (*Repert. f. Analyt. Chemie*, 1884, iv. 167, and 1886, vi. 202).

	Beginning Point of Melting of Fat.	Beginning Point of Melting of Fatty Acids Insoluble in Water.	Final Point of Melting of Fatty Acids Insoluble in Water.
	Degrees.	Degrees.	Degrees.
Butter . .	34–35	41–42	43–44
Another sort .	35–36	42–43	44–45
Beef tallow .	45–46	43–44	46–47
Beef fat . .	43–44	42–43	45–46
Mutton tallow .	50–51	49–50	53–54
Hog's lard . .	45–46	43–44	46–47
Goose-grease .	33–34	37–38	40–41

This method, as far as the fatty acids insoluble in water are concerned, is suitable for oils and other fats. The correction of the numbers found with reference to the length of the mercurial thread projecting outside of the bulb is generally omitted. For the method of executing such corrections and other points to be kept in view in the most delicate determinations, see Reissert (*Berichte der Deutsch. Chem. Gesell.*, 1890, p. 2239).

8. Examination for Free Fatty Acids.

§ 313. Recent fats of all kinds contain, along with the neutral triglycerides (glycerine esters) of the fatty acids, only minimum quantities of free fatty acids. If, on keeping, such free acids appear in large quantities, we call the fat, which has then an unpleasant taste and smell, rancid. The cause of rancidity consists of the following factors:—

1. The oxygen of the air combines with the fats (Duclaux, Ritsert), but only during the simultaneous action of sunlight, forming, according to Duclaux, oxy-fatty acids; according to Bonzynski and Rufi, free oleïc acid.

2. The activity of bacteria splits up fats. Hitherto no such bacteria are accurately known, but the greater durability of salted butter and the efficacy of other preservative agents seem to prove the joint action of bacteria, which was formerly enormously over-estimated (see § 316).

3. Lastly, we find in the seeds of plants ferments capable of splitting up plants, and which, on prolonged keeping, come into activity (Siegmund).

For determining the degree of rancidity, 50 *grm.* of the fat, which has been melted and decanted off clear, must be dissolved in about 50 *cc.* of ether, a few drops of an alcoholic solution of phenolphthaleine are added, and normal alcoholic potassa-lye[1] is added until a violet colour begins to appear.

[1] Alcoholic normal potassa-lye is obtained by dissolving about 60 *grm.* caustic potassa in 1 litre alcohol at 96 per cent. It is ascertained by titration with normal sulphuric acid how much more alcohol must be added to rectify the strength. Does not keep long, but turns slowly to a darker brown. Holde (Königl. Versuchs anstalt, Berlin) dissolves the caustic soda in alcohol at 50 per cent., as such a solution keeps better (*Chemiker Zeitung Rep.*, 1889, p. 349).

According to Köttsdorfer we say the fat has as many degrees of rancidity as cubic centimetres of normal potassa-lye are required to neutralise 100 *grm.* of fat. According to Besana, the more modest appellation, degrees of acidity, is more accurate (see § 317).

The method has latterly undergone various modifications. Besana, *e.g.*, extracts 10 *grm.* of oil three times with 45 *cc.* of alcohol at 95 per cent., and titrates the decanted alcoholic extracts with aqueous decinormal soda-lye. I have never experienced difficulties with the older, simple method.

9. Examination for Preservative Agents.

§ 314. In addition to common salt boric acid and salicylic acid are sometimes used. Salicylic acid can be shaken out from the melted butter with a solution of sodium bicarbonate as a sodium salt, and may then be separated from the fat by filtration. Boric acid may be extracted in hot water. (For details, see § 227 and § 231.)

10. Examination for Colouring Substances.

§ 315. The public, it is alleged, require yellow butter the whole year through. Butter, however, has a decided yellow colour only whilst the cattle consume green fodder. Hence, unfortunately, the custom of colouring the butter has become very general. Thus it is supposed that a satisfactory guarantee is afforded for the constant uniformity of the butter. Latterly the fashion of colouring butter is again declining.

The chief colouring substances used are:—1. Annatto = orleans = benefit (!) = carottine. A reddish-brown substance of intense tinctorial strength, obtained from the fruits of *Bixa orellana*. Met with in trade either as a watery paste or dissolved in oil. 2. Saffron, generally sophisticated with safflower, marigolds, or with other substances (see § 363). 3. Turmeric, a yellow powder from the roots of *Curcuma longa* and *rotunda*. 4. Juice of carrots (*Daucus carotta*). 5. For colours see next page.

All colouring-matters may be detected by shaking up the melted and filtered butter with a mixture of fifteen parts of methylic alcohol[1]

[1] Not methylated spirit.—*Editor.*

and two parts of carbon disulphide. The fat dissolves in the carbon disulphide and separates out, whilst the methylic alcohol floats above it. The latter takes up very freely the colouring-matters of annatto, saffron, and turmeric; little of the colouring-matter of carrots passes into the methylic alcohol, as it is very soluble in carbon disulphide, whence in this case the fatty stratum remains coloured.

A differential diagnosis of the several colours is not quite easy. Among the reactions laid down in the literature of the subject the following seem useful. The methylic alcohol drawn off with the syphon is evaporated down in small portions in porcelain capsules on the water-bath, and touched with one drop of concentrated sulphuric acid. Annatto, saffron, and carrot turn to a dark blue, more or less inclining to green; the tone of the colour is somewhat varied, and is much affected by the purity of the isolation. Saffron may be detected by its odour, even if present only in very small quantities. Turmeric is turned to a violet-red by concentrated sulphuric acid, and, in contradistinction to the other colouring-matters, which are scarcely, if at all, affected, it is turned brown by alkalies. Marigold behaves like carrot. The colouring-matter of safflower and the aniline colours possibly used: dinitrocresol ammonium, potassium, or calcium (saffron substitute, Victoria yellow), aniline yellow (naphthol yellow S), Martius yellow (naphthol yellow) have few characteristic reactions, but they also colour methylic alcohol. For further details see § 495 *a*. See also Martin (*Chem. Zeit. Repertorium*, 1887, p. 132), Leeds (*Chem. Zeit. Repertorium*, 1887, p. 188), Stebbins (*Chem. Zeit. Repertorium*, 1887, p. 232).

11. Bacteriological Examination.

§ 316. According to Lafar (*Archiv f. Hygiene*, xiii.), in the quantitative determination of the bacteria of butter, the best procedure is as follows: We introduce into 100 *cc.* of sterilised water about 0·1 to 0·3 *grm.* of butter, shake it well round after the water has been heated to 38–40° (not previously), and obtain thus a fine emulsion, of which quantities of from 0·05 to 0·5 are used for making up several plate-cultures. Butter is always very rich in microbia, the surface always more than the interior. Hence a layer of 1 *cm.* in thickness is always removed before taking the specimens. Lafar found in fresh butter in the interior on an average 10 to 20 million bacteria per gramme; amongst these were regularly two optionally anærobic short *rods*, one of them not liquefying: *Bac. butyri colloideus*, capable of growing luxuriant and slimy upon gelatine and agar and upon potato, approximating to the typhus bacillus, and the other liquefying, and in

its cultivations resembling the hay bacillus, but fluorescent, named *Bac. fluorescens butyri*, and perhaps in part the cause of the aroma of butter.

The sterilising of butter can be effected neither by salts nor by cold. If oxygen is excluded no rancidity is occasioned, in spite of the abundant presence of the optionally anærobic *Bac. butyri colloideus*. Laser (*Zeit. f. Hygiene*, x.) never failed to find in butter *Oidium lactis* either microscopically or by culture; it was especially easy to find in the caseine which separates out of butter at a brood-temperature (1 loopful yielded from twenty-five colonies to an innumerable swarm). Laser proposes to utilise its occurrence as a reagent for the presence of small quantities of butter. For staining these butter-organisms the method of Arens is excellent (§ 285).

B. Krüger found (*Centralblatt f. Bakterio'ogie*, vii. No. 14) that a growth of bacteria scarcely occurs upon melted butter, at least as far as the aërobic species are concerned. In "cheesy butter," badly washed, yellow and ill-smelling, he found a series of schizomycetes and saccharomycetes, one of the latter, *Saccharomycetes flavus lactis*, determining the yellow coloration.

Bang killed animals by dietetic tuberculosis on feeding them with butter obtained from the milk of cows suffering from tuberculosis of the udder. Other explorers have demonstrated a transmission of the bacilli of tubercle into cream and milk.

B. Decision upon Butter.

§ 317. According to Fleischmann good butter, properly prepared, has about the following composition:—

	Unsalted.		Salted.	
	Not Washed.	Washed.	Not Washed.	Washed.
Water . . .	14·0	15·00	12·00	12·5
Fat	83·82	83·20	84·54	84·5
Albumenoids . .	0·80	0·75	0·65	0·6
Not-fat, free from N.	1·20	0·90	0·61	0·4
Ash . . .	0·18	0·15	2·20	2·00

A butter of a good quality should not contain more than

15 per cent. of not-fat; that with more than 20 per cent. is not marketable (Agreements of the Bavarian chemists). Butter abounding in water is low in its nutritive value, insipid; if it is spread upon bread, water or butter-milk oozes out, which is not appetising.

The proportion of salt in salt butter rarely exceeds 2 to 2½ per cent., as even if 4 per cent. of salt is added a large part of the salt remains behind in the water in which it is kneaded up. The German navy does not accept as "keeping butter" any quality which contains more than 3½ per cent. of common salt. Vieth is not inclined to sanction more than 2 per cent. Further means of preservation except thorough washing (to eliminate butter-milk rich in microbia), the addition of salt and a low temperature, seem unnecessary for short preservation; butter for eating should be quite fresh; for the preservation of butter for voyages we may, in case of need, permit the addition of small quantities of boric or salicylic acid (of course with a formal declaration) if the means above-mentioned fail. I may pronounce this one of the cases where our present chemical means of preservation, cautiously applied, are admissible, especially as such preservative agents may be easily washed out before consumption.

Colouring butter, if well-prepared, sound, harmless vegetable colours—annatto,[1] saffron, carrots, &c.—are used, is hygienically unexceptionable, but scarcely makes the product more appetising. It is conceivable that butter may be rendered unwholesome by rancid colouring-matters in the course of putrescent decomposition. The use of poisonous colours, *e.g.*, dinitrocresol-potassium would be exceedingly likely to injure health (see § 457). We must strongly approve of the point of view adopted by the United States that every artificially coloured butter is to be legally regarded as artificial butter.

[1] Annatto is said occasionally to be worked up by the producers with urine, and to swarm with microbia. See Wagner's *Chem. Technology*. Edited by W. Crookes, F.R.S. Second edition, p. 523. London: Churchills. —*Editor.*

The mixture of butter with foreign fats[1] may be detected by the Reichert-Meissl-Wollny method, since all other fats contain smaller quantities of volatile fatty acids. Meissl required that the volatile fatty acids from 5 *grm.* of fat should consume at least 26 *cc.* of lye. Sendtner (*Arch. f. Hygiene*, i. p. 140) seeks to establish twenty-four. Recent Italian investigations have found lower values. Besana, who has published the most numerous analyses (114), found by Wollny's modification 21·8 to 30·2, Spallanzani in seventy analyses even 20·63 to 30·6 (*Chem. Zeit. Rep.*, 1889, p. 309).

Beef fat, consumes only	. . .	0·70 *cc.*
Hog's lard „	. . .	0·90 „
Margarine „	. . .	1·98 „
Vegetable fats „ . . .	from 0·6 to 1·0	„
Cocoa-nut fat „ . . .	„ 0·7 to 0·9	„

From these numbers it appears that an approximately accurate determination of the foreign fat added is not possible. To butter with an accidentally very high proportion of volatile fatty acids, large quantities of other fats may be added until the minimum value is reached.

If butter is burnt during melting it undergoes a loss of volatile acids. Such butter cannot be judged by the proportion of fatty acids. The conclusion of hygiene concerning the addition of foreign fats to butter has been already defined (§ 310).

Butter tastes and smells the more unpleasantly the more free fatty acids it contains.

According to Stockmeier (*Bericht über die viii. Versammlung Bayer. Chem.* in Würzburg, 1889), to which we are indebted for the most thoroughgoing information, fat quite free from acids has an insipid taste; fresh butter has from two to five degrees of rancidity; a rancidity of from five to six degrees is slightly unpleasant to smell and taste. Stockmeier met with no persons to whom butter of eight degrees of rancidity was other than unpleasant. After the use of such a product there sometimes occurs a feeling of discomfort, eructations, heart-burn, &c.; in two attacks of illness of this nature, after a moderate

[1] According to Huggenberg *all* the samples purchased as good, pure butter at Chemnitz contained from 60 to 70 per cent. of foreign fat (*Chem. Zeitung*, 1886).

use of butter, the same author detected a rancidity of 12 and 13·7 degrees. Melted butter-fat becomes rancid only very slowly. Cold fats of the same degree of rancidity taste less rancid than if hot. In winter rancid butter is much more readily sold without suspicion than in summer. The materials hitherto available are certainly in need of decided extension; but it is still, according to our present knowledge, probable that butter with from eight to ten degrees of rancidity and upwards may occasionally prove injurious to health.

According to Besana (*Chemiker Zeitung*, 1891, p. 410), the unpleasant rancid taste is not always proportional to the acidity. He found strongly rancid butter unfit for use with only 2·8 degrees of acidity, consequently other substances must also come into play. Quite similar results have been published by B. Fischer (*Jahresbericht der Chemischen Untersuchungsstation der Stadt Breslau*, 1891). Here butter with five degrees of acidity was several times found unpleasant, whilst once 15·55 degrees of acidity did not appear rancid to the taste.

Further investigations of a toxicological character are here necessary.

Heavy Metals.—Copper, lead, and tin in butter are to be judged not differently than if they were met with in other substances. If hot rancid fat is allowed especially to stand in copper vessels there is formed a fatty salt of copper with a green colour. Minimal quantities of copper are sufficient to produce a strong coloration of the fat, so that for the detection of copper it has been recommended to shake up an acidulated liquid and pour in a little oil.

The common assumption that the salts of copper, with the fatty acids, are more poisonous than other salts of copper is a fable (K. B. Lehmann). See § 484.

Milk containing pathogenic bacteria may yield a similar butter (compare § 301).

APPENDIX I.—MARGARINE AND ARTIFICIAL BUTTER.

§ 318. Margarine,[1] formerly known as "artificial butter," is a substitute for butter introduced into trade and prepared in different methods.

The best method (*Mége-Mouriès*) proceeds as follows: Fresh beef-fat (especially from the kidneys and omentum) is washed, chopped up

[1] Margarine is the name officially introduced as the name for substitutes for butter since July 12, 1887.

finely, melted at 50°, poured off from the non-fat, let cool at 24°, when the tristearine separates out in a crystalline state. The more easily liquefied trioleine and tripalmitine (called jointly oleomargarine) yield if churned up with water, milk, and a little butter-colour (§ 315), after salting and washing, a preparation of a butter-like taste, decidedly appetising.

The examination is conducted as for butter; to facilitate the control the law of the German empire prohibits the sale of margarine which contains more than an equal weight of milk, or more than 10 per cent. of cream.

Artificial butter at 100° has the specific gravity of 0·859 to 0·861, or at 35°, 0·9019; according to Reichert-Meissl only about 2 *cc.* of decinormal lye are consumed for 5 *grm.*

Hygiene has nothing to object to a product prepared exactly according to the above directions; it is not yet even proved with certainty that it is less fully utilised in the digestive organs than is butter. An addition of vegetable oils (oil of arachis, nut-oil, cotton-seed oil), as it is customary in many places, cannot be regarded as injurious to health. If, indeed, the fat of diseased animals (see Meat), fat from the establishments of knackers, or old, stale fat is used, if the margarine is not prepared with the utmost cleanliness, if flesh and connective tissue are not carefully removed from the preparation, if poisonous colours are used, &c., margarine may be harmful: products thus prepared are loathsome, and are unconditionally to be objected to.

In order to recognise an addition of margarine to cow-butter, Soxhlet has proposed to mix with all artificial butter small quantities of colourless phenolphthaleine, about 1 *grm.* to 100 lb.

If such butter is incorporated with natural butter, on melting the butter with a little water and adding some soda, the mass turns to a rose or a violet colour. For daily practice the ash of cigars may be substituted for soda. There is no hygienic objection to this proposal.[1]

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[1] The sale of margarine *under its own name* is perfectly free in Britain, a restriction which is much resented by the trade. In most other European countries the law is similar.—*Editor.*

APPENDIX II.—FOOD FATS.

§ 319. Among animal fats, along with butter and margarine, the following are extensively used for human consumption: hog's lard, beef-fat (especially that from the kidneys), and goose-grease. Among vegetable fats the principal are: the oil of olives, poppy-seed, beech-nuts, earth-nuts, sesame, walnuts, sun-flowers, cotton-seed; of late the consumption of purified cocoa-nut fat for food is constantly extending, a practice decidedly to be approved of.

We cannot here enter closely into the diagnosis of these substances; the detection of cheaper adulterants in the more expensive kinds is often very difficult, and not always certain. As general methods for investigation may be mentioned:

1. Determination of the specific gravity, § 311.
2. Determination of the melting and solidifying points of the fat and of its fatty acids, § 213.
3. Determination of the quantity of iodine which the non-saturated fatty acids (oleic acid) in the mixture are capable of combining with (Hübl's iodine number).

At the same time the odour, the taste, and—especially for cotton-seed oil—the colour reactions play an important part.

Whilst for all further details I refer to the special literature of the subject mentioned below, I mention the following methods of examination for certain coarser frauds.

1. *Examination for Proportion of Water and for Additions of Inorganic Substances in Solid Fats.*—All food fats should be free from water, *i.e.*, when melted they should form perfectly clear liquids. The proportion of water may be found approximately by setting a weighed quantity of fat for some time in a graduated cylinder in warm water. Any particles of tissues, which are scarcely likely to be present, subside to the bottom along with the water, as also any heavy-spar, gypsum, talc, &c. &c., which may have possibly been added, forming thus an aqueous and above this a fatty stratum.

If soaps are present, which are sometimes intentionally produced by adding lye to the fat in order to give it the power of taking up more water, the fat and the water separate from each other very imperfectly. We proceed then—and indeed always, unless we aim at merely approximate correctness—as for butter (desiccation upon sand).

2. *Examination for the Addition of "Mineral Fats."*—Liquid and semi-solid hydrocarbons (vaseline, paraffine oil, &c., which are therefore not fats at all) have often been used for the adulteration of fats in quantities up to 33 per cent. They may be detected by boiling 10 *grm.*

fat with about 10 *cc.* of strong potassa-lye and 50 *cc.* alcohol, until the solution is perfectly clear. If the alcohol is completely evaporated off in the water-bath the soap which has been formed must form a perfectly clear solution in the water; any portion which remains undissolved consists of a mineral oil, which may be separated from the soap by filtration through a wet filter, or by means of a parting-funnel. The paraffine may be further purified by dissolving in petroleum ether, filtering, and evaporating off the solvent.

3. *Examination for Rancidity and the Addition of Soap.*—If recent animal fat is shaken up with an equal volume of warm spirit and a little water is added to the liquid when cold, the reaction is rarely neutral, generally faintly acid, seldom strongly acid. The degree of rancidity is determined by titration as in butter. If the extract with warm alcohol has an alkaline reaction, lyes have been added and soap has been formed. For the certain detection of soap the melted fat must be shaken out with hot water, the solution of soap formed must be separated from the fat when cold, the fatty acids separated by means of sulphuric acid, dried and weighed, and the alkalies determined in the filtrate.

§ 320. Every fat of abnormal smell, taste, colour,[1] and consistence, until the true cause of the appearance is detected, must be regarded as suspicious. American lard, pressed out of bacon which has been treated with superheated steam, is smeary, soft, but not injurious.

The nutrient value and the wholesomeness of all the animal and most of the vegetable fats is approximately alike;[2] the presence of water reduces it, and it must therefore be objected to in all fats except butter. Soap, or the addition of lye, as a means for introducing water or less valuable fats, is to be condemned. A derangement of health by proportions too small to be detected by the taste is improbable; larger quantities of soap, as is well known, excite vomiting. The thought of consuming soap is disgusting to most persons. The rancidity of animal fats might be determined like that of butter (§ 317). I found in three samples of

[1] Kyll has observed green spots on butter owing to the harmless *Pleurococcus vulgaris*. It has a disgusting aspect.

[2] The sparing fusible fats are imperfectly utilised, *e.g.*, mutton fat. Compare Chocolate. In Portugal the incredible falsification of olive-oil with the oil from the seeds of the euphorbiaceous tree, *Jatropha curcas*, which are more drastic than castor-oil, is said to have occurred. Hiepe (*Rep. der Anal. Chemie*, 1885).

good olive-oil, supplied by respectable firms, 2·1, 4·4, and 5·4 degrees of rancidity; in two cheap "food oils," from small shops, 9·0 and 10·6.

Poisonous goose-grease has been described by Siedler (*Franks' Magaz.*, ii. p. 588). Its action was evidently due to ptomaines. According to Elsner, the fat of geese which have died of disease is of a sweetish, repulsive smell and taste.

Vaseline and other mineral oils are quite incapable of absorption; they therefore constitute at least worthless ballast for the digestive organs. In England some cases of violent illness have occurred in children, with intestinal symptoms, after the ingestion of vaseline, mixed with sugar, for a catarrh of the organs of respiration. Shepter Robinson (*Brit. Med. Journal*, 1886, p. 296), and Vincent (*Brit. Med. Journal*, 1886, p. 543).

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II. CHEESE.

§ 321. All the varieties of cheese, about 150 in number, differing in part fundamentally among themselves, are obtained from milk. The following may serve as an outlined classification:—

I. *Rennet or Sweet Milk Cheese.*—The caseine is precipitated from sweet milk by means of rennet (the ferment of the abomasum of calves):

1. Cream-cheese, or super-fatty cheese, obtained from cream or from new milk to which cream has been added, in which the percentage of fat is decidedly greater than that of caseine.
2. Fat cheese, from new milk, the proportions of fat and of caseine being more or less equal.
3. Semi-fat cheese made from partially skimmed evening milk and new morning milk in equal parts.
4. Lean cheese made from milk entirely or partially skimmed; the proportion of fat considerably below that of caseine.

II. *Sour Milk Cheese.*—The caseine is precipitated from sour milk on heating by the lactic acid.

III. *Whey Cheese.*—The albuminous matter which remains in the whey after Process I. is obtained by careful evaporation.

Group I. comprises by far the most numerous and most important sorts, that is, among soft cheeses; Limburg cheese and the various cream cheeses used as luxuries; among hard cheeses the Emmenthal, the Algäuer, North German, English and Dutch sorts, are all rennet cheeses. Group II. includes fresh curd- and hand-cheeses; Group III. plays no part in the markets of the world.

It is comprehensible that the proportions of fat, of albumenoids, and of water fluctuate enormously, according to the manner of preparing cheese; in addition, there are important differences involved in the ripening and storage with the co-operation of various bacteria, &c. The holes in cheese are produced by the development of carbonic acid.

It must further be mentioned that to many sorts, such as Gorgonzola, Roquefort, Stilton, the spores of moulds are intentionally added; the greenish tracts in these cheeses are mould-vegetations hitherto imperfectly studied botanically. Schabzieger cheese (herb-cheese) receives a flavouring addition of *Melilotus cærulea;* occasionally other spices are added, *e.g.*, cloves.

Careful bacteriological studies on cheese, and especially on its ripening process, have been made by Adametz and Von Freudenreich (see Bibliography). In 1 *grm.* of household cheese there were found 8½ millions of bacteria on an average, and in 1 *grm.* of ripe Emmenthaler a mean of 5½ millions (Adametz); in older cheeses, according to Von Freudenreich, often only 100,000; a number of species, chiefly aërobic, have been isolated and described. It would not be legitimate to enter more closely into this subject, as these preliminary studies are scarcely yet available for hygienic practice. Very recently Von Freudenreich has proved that the microbia which occasion inflammation of the udder if introduced into milk produce cheese which occasions flatulence (*Bacillus Guillebeau a, b, c*). Adametz and Weigmann have furnished strict proof that the formation of holes in cheese in general is occasioned by bacteria. Numerous quite recent investigations are occupied with further studies on the bacteriologic causes of the defects of cheese.

A. Examination of Cheese.

§ 322. Taking samples. Of smaller sorts of cheese we take the entire piece; of larger kinds, *e.g.*, Emmenthaler, we take a section tapering like a wedge from the margin to the centre, and after carefully removing the rind we comminute it, according to its consistence, either with a rasp or in a mortar, so as to obtain a perfectly uniform mixture, which for most rapidly obtaining portions for the several determinations is kept at a low temperature in a vessel fitted with a glass stopper.

The water, or the dry substance, is determined as directed for milk; from 2 to 3 *grm.* of the sample are dried at 100°, along with 30 *grm.* of sand (previously ignited), until the weight becomes constant. The quantity of the volatile fatty acids, or of the ammonium compounds which escape along with the water, is so trifling that, according to Sartori, it may be safely neglected.[1]

The fat[2] is obtained by extracting the dry substance with

[1] An examination with the senses furnishes experienced persons, but only such, with important data for a decision.

[2] To prove an addition of foreign fats, the fat must be extracted from about 40 *grm.* of cheese, the ether evaporated, and the fat further examined as directed for butter (§ 317). At present cheese is obtained from whizzed milk, to which margarine or vegetable oils have been added in place of the natural fat which has been removed (so-called artificial cheese).

ether according to § 214. Along with fat the etherial extract contains small quantities of free fatty acids, which may be determined, like butter, by titration (§ 313), as also lactic acid, especially in new cheese. Fatty acids combined with alkalies are left behind in the cheese. Their determination is not generally effected. The proportion of nitrogen is determined in a specimen freed from fat, but it is not recalculated as albumen, since cheese contains considerable quantities of amides, lecithin, nuclein, and other nitrogenous "non-albumen."

The ash is determined in 5 *grm.* of cheese, and further examination as directed for butter. Traces of copper are found in many cheeses; lead occurs in cheese enveloped in plumbiferous tinfoil. The presence of chalk, gypsum, soil (in Gorgonzola) is readily detected by an analysis of the ash.

Colouring-matters are used as for butter, but not to the same extent as formerly.

An addition of starch could be easily detected by means of iodine. Crushed boiled potatoes are occasionally stirred into cheap "curd-cheese." It is alleged that cheese is sometimes rubbed over with urine to give it a piquant flavour; the detection would be easily effected by extracting the rind with sodium carbonate, and testing the filtrate for uric acid (§ 197 *a*).

Certain characters for the detection of unwholesome cheeses are wanting; but when the smell and the taste differ from those of the sort in question, there is room for great suspicion. Cheese, however, has had a poisonous action, though presenting no remarkable properties. Sertuerner has described various cases of cheese-poisoning.

B. Decision upon Cheese.

§ 323. The chemical composition gives a decision on the nutritive value; in consequence of their high proportion of albumen at a cheap price, the half-fatty cheeses rank among our most valuable foods.

Unwholesome adulterations occur very rarely, and do not require any especial consideration. Concerning colouring-matters what has been said of butter applies here also. The superficial staining with *Croton tinctorium* and magenta,

commonly practised in Holland, is unimportant if the magenta is free from arsenic. Concerning the heavy metals see Butter (§ 317).

Cheese must be pronounced disgusting when it not merely displays small plots of mould on the surface, but is pervaded within and without with distinctly recognisable mould vegetations. The vegetations in Roquefort, &c., not recognised by the outside public as mould, are not to be hygienically objected to. Cheese is also disgusting when it is inhabited by great numbers of dipterous larvæ, if it has a putrid smell, is abnormally soft (deliquescent), or displays recent fermentation.

A more definite account of the changes in poisonous cheese is to be expected from thorough bacteriological-chemical researches. In the meantime we must be satisfied with a strict rejection of all cheese which excites in our senses even the most remote suspicion of unwholesomeness, as certain characters which point to the presence of cheese-poison are wanting. Injurious cheese has been repeatedly distinguished by a remarkable smell and taste (strong acidity, musty taste, remarkable softness, brick-like colour, a sharp taste). "Brick-cheese," and other soft cheeses, are more frequently poisonous than hard cheese. Tyrotoxicon, which has been repeatedly found in poisonous cheese in America, is sought for in a crushed or comminuted portion (§ 298); for the detection of other ptomaines see §79 *a*. Tyrotoxicon is highly poisonous.

Black cheese (F. J. Herz, *Milchzeitung*, 1886, p. 498 and Hueppe, *l. c.* 1886, p. 659), occasioned by the development of a black saccharomycete, is harmless but repulsive. Blue cheese is said to occur frequently in Holstein, and notwithstanding its unappetising, blue-stained colour and its greyish-blue spots, it is consumed without injury (Von Klenze, see Bibliography). Hitherto the careless use of iron implements has been considered a main cause of this defect. Recently De Vries has detected in blue Edam cheese motionless bacteria, not yet closely described, which generate a colouring-matter only in the absence of air (*Milchzeitung*, 1888, Nos. 44 and 45).

Artificial cheese, injurious to health, has not yet been observed; its nutritive value will be equal to that of natural cheese similar in composition; its relishing quality generally leaves much to be desired.

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See generally the journals mentioned under milk.

The literature of cheese-poison is to be found in Senkpiehl, *Ueber Massenerkrankungen nach Fleischgenuss,* &c. Dissertation, 1887, as also in the *Jahresberichten für Pharmakognosie, Pharmacie, und Toxikologie von Beckurts.*

The English works referred to under Milk and Butter may also be consulted.

SECTION X.

FLOUR AND BREAD.[1]

§ 324. In our districts only wheat, spelt, and rye play an important part as bread-stuffs. In mountainous regions and in northern countries there are used also barley, oats, and buckwheat; and in the south, maize, rice, and several sorts of millet.[2] Buckwheat and rice do not yield bread, but only porridge, &c.

With us, along with *Triticum vulgare*, several species belonging to the genus Triticum are cultivated, although to a less extent: *Triticum durum*, especially grown in the south of Europe, yields hard grain, very rich in gluten, and is used for the manufacture of maccaroni; *Triticum turgidum*, cultivated especially in England and Holland, yields a flour rich in starch, poor in gluten, and therefore bad to bake; *Triticum dicoccum*, and *Triticum monococcum*. In these two kinds, as also in *Triticum spelta*, extensively grown in South Germany, the grains remain after thrashing inclosed in the gluma.

Of rye (*Secale cereale*), rice (*Oryza sativa*), and maize (Indian corn or mealies, *Zea mays*) only one species of each is cultivated, though there are several varieties.

Buckwheat (*Polygonum fagopyrum*) is not a graminaceous plant, but belongs to the Polygonaceæ.

A. Examination of Flour.

§ 325. By flour we understand the product of grinding grains of wheat, freed from the seeds of weeds, from dirt, and from their own husks, between millstones or fluted rollers.

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[1] Some complete analyses are given in Table IX.

[2] In Britain rye is not now used for bread, and is cultivated only as green fodder for cattle. Next to wheat, oats are the commonest grain in the north of England and in Scotland. Barley is extensively used in North Africa and Western Asia.—*Editor.*

In modern advanced milling a series of very different white flours are obtained from wheat, the whitest qualities being obtained from the interior of the grain. There are distinguished, *e.g.*—

00. Imperial select flour.	4. Flour for rolls.
0. Select flour.	5. White pollards.
1. and 2 Bakers' select.	6. Black pollards.
3. Pastry flour.	7. Bran.

Groats, grits, and dust are, in an ascending series, names for preliminary stages of flour. The waste-products of milling are used for feeding domestic animals.

The finest wheat flours are poor in albumen (10·1 per cent.), the coarsest contain from 13 to 16 per cent. of albumen, along with an abundant admixture of cellulose. The kind of wheat used is very important for the proportion of albumen.

Rye flour is of a darker colour, and is not ground as finely as wheat.

Admixtures of bran can be detected by spreading out the sample upon a dull, dark paper. The expert can estimate the degree of contamination with bran by the colour and the feel of the flour. The examination of flour involves the determination of the following points:—

1. Proportion of water, ash, albumenoids, and, if necessary, fats.

2. Presence of foreign constituents: mineral powders, the seeds of weeds, diseased grain.

3. Presence of products of decomposition, moulds, &c.

1. Chemical Examination.

§ 326. *Proportion of Water.*—We proceed exactly as directed in § 209.

Flour containing a normal amount of water, if pressed in the hand, forms a loose lump, which readily falls asunder; damp flour clots in the sacks, and still more if pressed in the hand and keeps badly (§ 332).

Fat and Albumenoids.—We proceed exactly according to §§ 214 and 211.

The most important albumenoid substance of grain is gluten.

The baking property of flour depends on the proportion of gluten ; if it is too small, or if it has been modified by processes of decomposition from the germination of the grain, from too prolonged storage, or from having been kept in a room which had been sulphured, it may no longer be in condition to yield a compact dough which will rise well.

A simple method determines the gluten in wheat (not in rye) accurately enough for practical purposes ; 50 *grm.* of flour are well mixed in a capsule with an equal weight of water, and allowed to stand for thirty minutes to one hour. The paste is then collected in a fine linen cloth which is closed up in the form of a bag, and the paste is kneaded under the water flowing from a tap. The starch runs out in a milky suspension, whilst the gluten remains behind yellow, tough, and plastic. After some time the cloth is removed from the gluten thus approximately purified, and the kneading is completed by hand until the water runs off clear. The fresh gluten, well pressed, ought to amount to 25 to 30 per cent. of the weight of good wheat flour fit for baking, or 12 to 15 per cent. when dried. Bad flour yields little, or dark coloured, slimy gluten, deficient in plasticity.

The proportion of gluten is higher in richly nitrogenous wheats than in such as are poor in nitrogen, but the quantities are not proportional. Heinrich and Meyer (*Centralblatt f. Agrikultur-Chemie*, 1890, p. 342) found a Danish sort with 1·84 per cent. nitrogen and 15 per cent. gluten ; and in a German sort, 1·50 per cent. nitrogen and 6·3 per cent. dry gluten. Rye yields no plastic gluten, but a deliquescent gluten which cannot be washed.

Halenke and Möslinger, as they repeatedly obtained by washing the normal proportion of gluten from flour which did not bake well, recommend the following test. A paste is made up of 50 *grm.* flour and 25 *grm.* water, and laid underneath a glass bell. Bad baking flour often appears shiny in half an hour and begins to deliquesce, and after twelve hours the paste is quite melted away.[1] Paste from good flour is then still dry, firm, and elastic. I have no experience on the subject.

The suitability for baking can be directly tested (both for rye flour and wheat flour) by measuring the expansion of a piece of dough on baking it in a tube rubbed over with oil in an oil-bath. The apparatus founded upon this principle is called the aleurometer. The tougher the gluten the better it retains the carbonic acid evolved, and the greater is its suitability for baking.

A large addition of common salt renders it possible to bake bread of good appearance even from flour of bad quality. Alum, copper sulphate, and lime-water have a similar effect.

The proportion of cellulose may be accurately determined according to the directions in § 221.

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[1] Formerly, when every family in the North of England baked its own bread, the complaint was general after a cold, wet summer and autumn that "the dough ran away out of the oven."—*Editor.*

§ 327. *Ash*[1] *and Inorganic Additions.*—The quantitative determination is effected as in § 210. Wheat and rye flour contain, according to their degree of fineness, from 0·5 to 1·8 per cent. of ash; the proportion of ash is higher the more of the bran, which is rich in silica, is left in the flour; from 0·5 to 1·0 is present in ordinary qualities. The flour of leguminous seeds contains from 2·5 to 3·3 per cent. of ash.

If about 10 *cc.* chloroform, and then about 5 *cc.* of flour are put in a test-tube, which is covered with the thumb, shaken, and allowed to stand, the flour, which has about the same specific gravity as the chloroform, remains suspended, *i.e.*, floating, whilst mineral matter present falls to the bottom as a whitish powder. Flour is rarely quite free from such matter (from the abrasion of the millstones and sand); but if the grain has been well cleansed and not sophisticated, a minimum quantity only should be found. If the deposit is large, a larger sample of flour is treated in the same manner, the sediment is collected by pouring off the meal and the chloroform, and examined as follows. There may occur:[2]—

$CaCO_3$ = calcium carbonate, marble or chalk-powder.
$\underbrace{MgCO_3 + CaCO_3}$ = dolomite, a mixture of calcium and magnesium carbonate.
$CaSO_4$ = calcium sulphate, gypsum.
$PaSO_4$ = barium sulphate, heavy spar.
Silica and calcium aluminium silicates.

If the sediment effervesces with hydrochloric acid, CO_2 is present; if it readily dissolves entirely, there are merely carbonates, and perhaps a little calcium sulphate. Larger quantities of gypsum dissolve only on long boiling with much water or hydrochloric acid (or slowly in sodium bicarbonate in the cold); an addition of barium chloride to the hydrochloric solution reveals the sulphuric acid as white $BaSO_4$. If, after repeated energetic treatment with an excess of hot dilute hydrochloric, there still remains an undissolved residue, it is heavy spar, which defies all solvents, or possibly quartz-powder or silicates.

In order to decide whether magnesium or calcium has been dissolved in the hydrochloric acid in succession, they are tested for in succession according to § 187.

[1] The ash of pure grain is rich in P_2O_5 and potassa, poor in lime and sulphuric acid. This is altered by an addition of gypsum. Traces of copper are always present (see Bread), Kassner once found 0·1 *grm.* nickel per kilo grain.

[2] It may happen that the addition of copper or zinc sulphate or alum, which in some places is very common in baking, is made to the flour. For detection see Bread. For lead, which may be derived from millstones carelessly mended with lead, see § 481.

A residue insoluble in boiling hydrochloric acid, several times renewed, which may be barium sulphate or silica, or a sparingly soluble silicate of calcium and aluminium, may be mixed dry in a finely powdered state, with pure anhydrous sodium carbonate, and melted together. There are formed $BaSO_4 + Na_2CO_3 = BaCO_3 + Na_2SO_4$, if heavy spar is present. The melt is extracted with water to remove the Na_2SO_4; the $BaCO_3$ insoluble in water may be easily dissolved in HCl, and on adding dilute sulphuric acid to this solution insoluble $BaSO_4$ is reprecipitated. If it has not been previously boiled with HCl, and if $CaSO_4$ is still present, we have after fusion $CaCO_3$ along with $BaCO_3$, and after dissolving the matter insoluble in water in HCl, we have $CaCl_2$ along with $BaCl_2$. A 25 per cent. solution of ammonium sulphate precipitates here merely $BaSO_4$; the lime may be thrown down from the filtrate by means of ammonium oxalate and ammonia.

If silicates were present there will be formed on fusion SiO_4Na_4, and SiO_3Na_2 sodium silicates, which are soluble in water; on the addition of hydrochloric acid to the aqueous solution there is thrown down gelatinous silica $Si(OH)_4$ and SiO_2H_2, which, on evaporation to dryness, moistening with strong hydrochloric acid and reheating, is converted into the insoluble anhydride SiO_2.

2. Microscopic Examination of Flour for its Origin.

§ 328. Sophistication of wheat flour with rye flour does not occur; bad wheat flour is sometimes used as a substitute for rye, barley waste has been ground up and added to other kinds of flour, but these are rather rare cases. Such substitutions would have no hygienic importance. Here it may be merely remarked in general that wheat and rye starch in mixtures cannot be distinguished with certainty (see § 345); on the other hand, the fragments of cells, hairs, &c., occurring in the flour furnish data for a diagnosis. (See Bibliography, § 346, and the remarks in § 338.)

A very good characteristic is the colour of the layer of gluten cells. In rye it is commonly from light to dark blue, whilst in wheat no such colours have been hitherto observed (*Arch. f. Hygiene*, iv.).

3. Chemical and Microscopic Detection of Diseased Grains of Cereals and of the Seeds of Weeds.

§ 329. It may be important to detect in flour the seeds of weeds. If the meal is coarse (groats), the expert, after passing a sample through a sieve, will be able with the naked

eye to detect any characteristic fragments of weeds, especially tares—*Agrostemma githago*, *Centaurea cyanus*, among the coarser fragments. By seeking out fragments of the various kinds of seeds, weighing them, and recalculating them, a proportion of the most important kinds of weeds, of fragments of soil, mouse dung, &c., may be determined. Thus, *e.g.*, I found in a sample of bad, coarsely ground rye flour from North-Western Germany in 100 *grm.*—

Unground grains	0·1
Constituents of flour coarser than 2 mm.	17·6
Coarser than 1·25 „	30·1
Coarser than 0·5 „	29·9
Smaller than 0·5 „	22·3
	100

In the 47·7 *grm.* of the two coarsest fractions there were—

Tares	1·792
Shells of tares	0·050
Agrostemma githago	0·070
Centaurea cyanus	0·060
Ergot	0·026
Various	0·006
Earth + mice-dirt	0·012
	2·016

Or in 100 *grm.* flour—

Seeds of weeds	4·02
Poisonous weeds	0·20
Dirt	0·02

In other samples, used for making bread in rural districts, I found 0·15 per cent. of dirt. In finely ground flour the detection by botanical means is much more difficult, and here chemical methods must be tried in the first place. (See § 330.)

For diseased grains which, like the seeds of weeds, ought to be removed before grinding, a microscopic examination is in part necessary. An examination of the unground wheat is always much easier, since most of the seeds in question have a form which is easily recognised with the naked eye.

The seeds and fruits of weeds which occur most frequently are derived from *Ranunculus arvensis* (meadow crowfoot), *Adonis æstivalis*, *Delphinium consolida* (field larkspur), *Sinapis arvensis* (wild mustard), *Raphanus raphanistum*, *Rapistrum rugosum*, *Viola tricolor*, *Papaver rhœas* (wild poppy, and other sorts of poppy), *Vicia angustifolia*, *V. cracca*, *V. sativa* and other sorts of tares, species of *Lathyrus*, *Agrostemma githago* (corn-cockle), *Caucalis daucoides*, *Centaurea cyanus* (corn-flower or corn-bottle), *Galium tricorne* and other rubiaceous plants, species of *Galeopsis*, *Rhinanthus hirsutus*, and some kindred species, *Melampyrum arvense*, *Convolvolus arvensis*, *Lithospermum arvense*, *Lolium temulentum* (darnel), *Bromus secalinus*, and numerous other grasses. Along with these there are never absent in wheat, which has not been cleansed, grains affected with secale and other diseases; mice dirt, bodies of dead beetles, &c., are more rare. For representations see Harz (Bibliography), and in Dammer's *Lexicon der Verfalschungen*.

1. DETECTION OF THE SEEDS OF WEEDS WHICH ARE HYGIENICALLY MOST IMPORTANT.

§ 330. 1. *Agrostemma githago*, L. (cockle or corn-cockle).—The large, characteristic seed, of a dull black colour, beset with fine protuberances, and having obtuse angles, contain, along with an intensely white starch, the poisonous glycoside (Agrostemmasapotoxin) of the saponine group.

In coarse flour the black, warty fragments of the shells of the seeds can be easily recognised microscopically after the sample has been boiled for some time with hydrochloric acid at 5 per cent. In fine flour either the very large, characteristic starch-grain (as much as 120 μ in length), consisting of the minutest particles, must be recognised microscopically, or saponine must be detected chemically. For this purpose a large portion of the meal is extracted with hot alcohol at 70 per cent., the alcohol is completely driven off on a briskly boiling-water bath, and the extract is mixed with water. Even very small proportions of saponine may be recognised by the strong froth which they produce if mixed up with water. Similar starch grains are found in Spergula and other field-weeds. See Franz Beneke (*Repert. f. Analyt. Chemie*, vol. v. No. 13).

Bread from wheat flour containing a considerable addition of cockle-seed was found by the author to have a bluish cast, not liable to be mistaken for bread containing the seeds of Rhinanthaceæ; the colour was evidently due to the husks of the seed.

2. *Tares.*—There are found in grain numerous seeds of leguminous plants, most frequently tares: *Vicia sativa*, *V. angustifolia*, *Ervum tetraspermum*, *E. hirsutum*, &c., and

some species of Lathyrus. According to Vogl, acid alcohol (Vogl's alcohol, *i.e.*, alcohol at 70 per cent., with 5 per cent. hydrochloric acid), takes, on soaking with fragments of tare-seeds, or more rapidly on heating, a rose, purple, or violet colour. Bean meal, according to Vogl, behaves in a similar manner. The husks of the seeds have a very characteristic structure.

With comminuted white beans steeped in acid alcohol I observed merely a faint yellow colouring; chamois-coloured beans took a yellow with a rose-coloured tint, whilst speckled and dark beans gave a splendid coloration from red to violet. With the dark seeds of *Vicia angustifolia* I obtained a fine rose-coloured extract; with the pale seeds of *Vicia sativa* only a pale yellow extract with a very faint reddish tint. *Ervum hirsutum* gave a splendid red, *Lathyrus sativus* a very fine violet, *Trifolium repens* a red. Acid alcohol takes also a rose colour with a variety of rye—by no means rare—with many gluten-cells of a blue colour (*Archiv f. Hygiene*, i. and iv.).

3. *Rhinanthaceæ.*—The seeds of *Melampyrum arvense*, L., *Rhinanthus major, hirsutus*, &c., along with other seeds of the same family, contain the colourless, non-poisonous glycoside rhinanthine, which is split up by acid alcohol into a blue or blueish-green body, rhinanthocyan, and sugar. (For particulars see K. B. Lehmann, *Archiv f. Hygiene*, iv.)

The seeds are fundamentally different, those of Rhinanthus being winged, reniform, and flat; those of Melampyrum resemble wheat, and when fresh are yellowish white; on keeping they become blue-black or black.

In flour the Rhinanthaceæ are easily detected if they occur in the proportion of from 1 to 2 per thousand, by boiling for five minutes with Vogl's alcohol. Even minimum traces may be detected by a blueish-green coloration. The alcoholic extract has a well-defined spectral band between C and D, almost identical with that of an indigo solution; even in concentrated solutions it leaves one-third of the space from C free. Alkalies change the colour through red into yellow. On examining the flour after boiling with hydrochloric acid, the dark-coloured fragments of tissue can be easily referred to Melampyrum or Rhinanthus, which are very different in their structure. (Figures: *Archiv f. Hygiene*, iv.)

Bread baked with flour containing the seeds of the Rhinanthaceæ (even 1 or 2 parts per thousand) has a colour varying between violet-brown, violet, and blue-black; sometimes there are only single spots, but if the seeds are plentiful wheaten bread may be rendered entirely blue-black. An extract with acid alcohol takes here often only a very

pale colour. A microscopic examination of the darkest particles of tissue leads easily to an exact decision as to the genus of the Rhinanthaceæ.

4. *Lolium temulentum* (darnel).—On the determination of this species of grass, the bearded fruits of which are sometimes not rare among uncleansed grain, recent investigations are wanting. In Möller its microscopic structure is very accurately described and figured. The starch-grains, like those of oats, are composed of numerous granules. Acid alcohol takes up a dirty, greenish yellow colour, which is not characteristic.

Other seeds of weeds are partly not to be detected with certainty, and partly their detection offers no present interest.

Nevinny found at Vienna, in 1887, out of 713 samples of flour 15 per cent. contaminated in this manner. There were recognised :—

Tares	65 times
Agrostemma	10 „
Darnel	12 „
Combinations of these three kinds . .	6 „
Tares and traces of *Tilletia caries* . .	Once.

2. DETECTION OF DISEASED GRAINS.

§ 331. 1. *Anguillula tritici.*—Often found in masses in wheat in damp seasons. The grains remain small, short, thick, indistinctly three-cornered, and blackish. In the grains thus characteristically modified and steeped in water for some hours, the microscope reveals briskly mobile worms from 0·6 to 1 *mm.* in length. The disease is called gout or cockle-disease, from the slight resemblance of the grains to the seeds of Agrostemma.

2. *Ergot.*—This name is given to the permanent mycelium (sclerotium) of a fungus, *Secale cornutum*, which grows at the expense and in place of a grain of corn.[1] (Rye frequently, barley more rarely, wheat rarely, wild grasses, such as Lolium, Bromus, Molinia, &c., not uncommonly.) Upon

[1] From this there is developed upon moist earth a pedunculated support (claviceps form), the spores of which germinate upon the young plants of grain, and grow into them as far as the embryo, and then become conidia (sphacelia form). The ultimate stage is the formation of the permanent mycelium (*Secale cornutum*).

Lolium perenne it is universally diffused in autumn at Würzburg, Darmstadt, Zurich, Schafhausen, &c. The sclerotia are stout grains, from 1 to 2 or 4 *cm.* in length, from 2 to 8 *mm.* in thickness, curved, furrowed, violet-black externally, with whitish stripes within. At present it is rare to find ergot in flour, as it is carefully sought out on account of its value as a drug.

Detection in Flour.—Preliminary test: A reagent-glass is filled to one-half with flour and then up to one-fourth with soda-lye; the mass is then well stirred up with a glass rod, stoppered, and allowed to stand. On lifting the stopper after some time (thirty minutes), the herring-odour (trimethylamine) is never wanting if ergot is present; but it may also occur, especially in spoiled grain, in the absence of ergot. The following simple method is preferable: A test-glass one-fourth full of meal is extracted twice in succession with boiling absolute alcohol, eliminating thus small quantities of a yellow colouring-matter. Acid alcohol (§ 330) is then added, which takes up a brownish red colouring-matter, gradually in the cold, but better on the application of heat; 2 per cent. may be just recognised, but 5 per cent. very distinctly.

If examined with the spectroscope, the red solution shows two bands (I. at D.$\frac{2}{3}$E. and II. at E.$\frac{1}{3}$F.). This reaction gives good results also in bread.

The best method of detection, though rather circumstantial, is that given by C. Hoffmann: 10 *grm.* meal, 20 *cc.* ether, 10 drops sulphuric acid at 20 per cent. are mixed together, allowed to stand for thirty minutes at the temperature of a dwelling-room, put upon a filter, and after the liquid has run off washed with ether until 20 *cc.* of filtrate have been obtained. To this filtrate there are added from 10 to 15 drops of a saturated solution of sodium bicarbonate. After a short time the latter settles to the bottom of the vessel, of a fine violet colour, containing all the colouring-matter. The ether is decanted off, the violet solution is supersaturated with dilute sulphuric acid, and the colouring-matter is taken up with fresh ether. In this manner 0·1-thousandth part can be detected with certainty.

In coarse meal, for a quantitative determination fragments of ergot are sought out; pieces of 2 to 3 *cbmm.* yield a good colour reaction with a little acid alcohol, and they may also be easily recognised microscopically. They consist of entangled colourless fungoid hyphæ, which

break up into short fragments, and in quantity contain colourless drops of oil, which reflect light strongly. The adherence of fragments of the indistinctly cubic, violet-red zone of rind may assist the diagnosis, which moreover is very easy with the experience obtained from some comparative preparations of the smallest fragments. If the flour has been ground very fine, the chemical detection is more certain, although a quantitative determination has not yet been effected.

3. *Ustilagineæ.*—A number of fungi of the family of the Ustilagineæ destroy the grains of corn.

Ustilago carbo, Tulasne (smut, or smut-brand).—Found on oats, barley, wheat, sometimes on meadow-grasses. The spores form a black, dusty powder, occupying the gluma in place of the grain, which is entirely destroyed. The spores are almost regularly globular, light brown, smooth. Fig. 104, *c*.

Ustilago maydis, DC.—Converts various parts of the young maize plant (pod, stem, and leaves) into large boils, containing enormous masses of spores. Spores roundish or egg-shaped. Surface warty, brown.

Tilletia caries and *Tilletia lævis* (canker, or stinking disease of wheat).

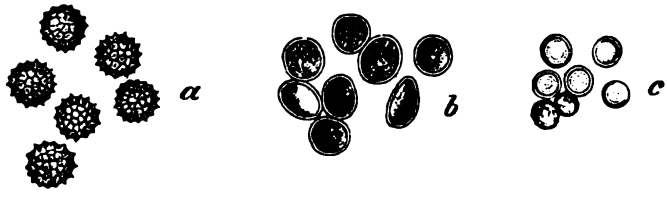

FIG. 104.—Spores of Ustilagineæ according to Möller (magnified 300 diameters).

—The fungi, which macroscopically are very similar to each other, fill the grains with a moist, smeary, black powder.

Microscopically the spores of Tilletia are larger than those of Ustilago. In *T. caries*, Fig. 104, *a*, they are globular or roundish ellipsoidal, with net-like ridges; in *T. lævis*, Fig. 104, *b*, they are more irregular and smooth.

Numerous other species of Ustilago, Tilletia, and of other allied genera destroy rye, millet, &c. They are not yet universally distributed in our regions.

The so-called black disease of grain, occasioned by fungi, is hard to determine and often imperfectly developed, belonging to the genera Macrosporium, Helminthosporium, Torula, Alternaria, &c., sometimes attacks especially rye; the grains become covered with a thick grey coating, not easily removed, and are said to be rendered poisonous. Compare Von Thümen (*Veröffentlich. der K.K. Versuchsstation zu*

Klosterneuburg, near Vienna, No. 13, 1890, and *Centralblatt. f. Bakteriologie*, viii. 277). The important Uredinaceous species, *Puccinia graminis*, attacks only the stems and the leaves, not the grains, as also probably *Cladosporium herbarum*.

4. Examination of Flour for Soundness.

§ 332. Fresh, good flour has a pleasant characteristic odour and mild taste. Decompositions of the flour by fungi may, for the most part, be directly recognised: a bitter, mouldy, sharp, irritating taste; a dull, mouldy smell, and sometimes a grey colour.

Even fresh flour always contains rather numerous spores of moulds and bacteria; by plate-cultures of from 1 to 5 *mgrm.* of flour we easily obtain an insight into the numerical relations. Accurate enumerations are still wanting. See Bernheim (*Chem. Zeitung*, 1889, p. 513).

According to these researches fresh flour taken from the grinding-shafts of a mill contains per milligramme from 35 to 200 microbia, among which there are many hyphomycetes. Bought polenta meal contains from 400 to 500, mondamine about 120.

If flour is allowed to lie, especially in a damp place, the number of microbia increases rapidly. According to Poehl (*Ber. d. d. Chem. Gesellsch.*, 1883, p. 1915) sugar is formed from the starch, and further, if kept moist, lactic and butyric acids, peptone, and poisonous fission-products of the latter. Storage in sacks for two to three years gives occasion to the origin of poisonous alkaloids, which may be extracted from the meal by ether, and removed from the ethereal extract by means of water (Ballaud., *Journ. de Pharm. et de Chimie*). But even if there are no especially unfavourable conditions in its preservation, or it is kept too long, flour in the summer months easily becomes "warm," the gluten is thereby rendered "short," and the flour is fit for baking only if it is ground over again with an addition of sound flour (§ 326). It must then be rapidly used, otherwise the added meal is decomposed in the same manner. According to Aimé Girard (*Annal. de Chimie et de Phys.*, ser. vi. vol. iii. p. 289) the spoiling of the meal is determined especially by decompositions of the fat in the germ, in which it is abundantly present. The germ should therefore be removed to render the flour capable of keeping.

Flour from sprouted grain (wheat or rye) displays remarkable radiating clefts, beginning at the margin, a distinct stratification of the starch-grains, the margin of which often

appears as if gnawed or notched (Fig. 105). But latterly the certainty of these criteria has been strongly doubted. According to Hilger and Günther the acidity of the flour from sprouted grain (lactic acid) is increased from 0·02 to 0·04 per cent. to 0·06 or 0·11 per cent., and in like manner the maltose from 0·17 to 0·32 per cent. to 0·51 or 1·1 per cent. Acari are not rarely found, and seem at times to be transferred to man[1] (see *Centralblatt f. Bakteriologie*, i. 429, and vi. 422).

B. Examination of Bread.

§ 333. For the preparation of bread a thin preliminary paste is first made with a part of the flour mixed with yeast or leaven; it is then allowed to stand covered for some hours at a gentle heat, and the remainder of the meal is kneaded in. When the dough is ready it contains from fifty to sixty parts of water[2] to a hundred parts of flour. The processes in the dough are threefold (see Dünnenberger in the Bibliography:—

1. The cerealine, a diastatic unorganised ferment pre-existing in the grain, partially converts the starch into dextrine and maltose.
2. The yeast-cells, added either in the yeast or in the leaven, form from the maltose carbonic acid and alcohol.
3. If leaven was used containing numerous schizomycetes along with the yeast-cells, there are always formed a little lactic, acetic, and butyric acids.

The various recent proposals to produce carbonic acid in the paste, not by fermentation but by the transformation of salts ($HCl + CO_3Na_2$, Liebig), ($PO_4CaH + CO_3NaH$, Horsford) [$C_4H_7O_6K$ (tartar) + CO_3NaH, baking-powder] or to prepare the dough with water saturated with carbonic acid under pressure (Dauglish) are free from

[1] Bakers' itch.—*Editor.*

[2] In the preparation of rolls milk and also butter are frequently added. Unfortunataly bad, half-spoiled materials are often used, which, to say the least, are not appetising.

objection hygienically, but hitherto they have not come into general use.[1]

The pores in the bread are formed by the expansion of the carbonic acid and the evaporation of alcohol in the baker's oven, the temperature of which ranges from 200° to 270°, and at the same time a further portion of the starch is converted into dextrine. The interior of the loaf only reaches temperatures of about 100°; in the crust carameloid substances of pleasant taste are formed by the high temperature at the surface.

100 *kilos.* of flour yield from 112 to 120 *kilos.* of long loaves with a thick crust, or from 120 to 135 *kilos.* of round loaves with a thin crust. In German ammunition bread (Lenz): 50 *kilos.* meal + 450 *grm.* salt yield twenty-three loaves of 3 *kilos.* each. It must not contain less than 50 per cent. of solid matter, not more than 2 per cent. of ash, and 3 per cent. of bran.

In the examination of bread, in addition to the points discussed in speaking of bread, we are interested in a series of further questions.

Appearance.—Wheat bread has a light colour, rye bread is dark. The sorts of wheat flour poor in bran are chiefly used, which yield a paler bread; in rye meal, in addition to the admixture with more bran, the action of the acidity of the dough upon the gluten comes into play as a darkening agent. Bread is rendered blue or violet by seeds of the Rhinanthaceæ (§ 330). Flour from badly cleansed grain scarcely ever yields light-coloured bread.

If bread is baked for an insufficient time, if the oven is too cool, if the dough has been made too watery, or the gluten has in part lost its fitness for baking, there is produced an imperfectly porous, dense, watery bread sometimes traversed by water stripes (portions containing much moisture and too little air). On moulds (hyphomycetes), see § 341.

[1] In England leaven is never used except in the preparation of oaten bread. The addition of potatoes is legalised, though it is a fraud on the consumer, since their value, both nutritive and commercial, is inferior to that of wheat flour. Baking-powder, and the solid, so-called German yeast, are used to a larger extent than in most parts of the European continent.—*Editor.*

For determining the proportion of moisture a large piece is cut out, so that the proportion of crumb and crust may be the same as in the loaf. From round loaves the sample is taken by means of two radial sections; from long loaves a slice of about 2 *cm.* in thickness is cut right through. For weighing an apothecary's balance is used, and the weight is determined accurately to 1 *cgrm.* Before drying the bread is torn into small pieces.

§ 334. The examination for ash (the ash of the flour + sodium chloride), albumen, fat, and cellulose is executed as usual.

In Belgium, North France, and England, the dough[1] is not uncommonly mixed with a little copper sulphate or alum to cause it to rise more quickly and to appear whiter; 50 *mgrm.* of copper sulphate per kilogramme of dough, or 3 *grm.* of alum have a striking action (Bruylant, *Rev. Internat. des Falsific.*, 1889). Especially flour from sprouted corn, or flour injured in its baking properties, by storage, &c., can be baked after receiving these additions, because, as it is alleged, the deliquescent constituent has been precipitated again. Formerly zinc sulphate, which is much less effective, was used along with copper sulphate.

Alum is detected in flour, according to J. Herz, as follows: A test-glass is filled with meal to one-third of its capacity, a little water is dropped in with the washing-bottle, and the meal is thoroughly moistened by striking with the hand. Next we add a few cubic centimetres of alcohol and a few drops of freshly prepared tincture of logwood (5 *grm.* logwood with 100 *cc.* of alcohol at 96 per cent., allowed to stand and filtered), the thick paste is shaken up, the glass is filled up with a saturated solution of sodium chloride without shaking again. From 0·05 to 0·1 per cent. of alum are recognised by a blue colour and 0·01 per cent. by a violet colour. Bread is steeped for six or seven minutes in tincture of logwood and pressed out. In presence of alum it takes in two or three hours a violet red, but otherwise merely a yellow colour. The sensitiveness is the same as in flour. Check experiments should be made with bread which is certainly free from alum, and with such as has been moistened with a solution of alum.

[1] Steeping the seed-corn in liquids containing copper or arsenic has no influence on the composition of the grain reaped.

Copper sulphate may be extracted from meal by water; the solution is coloured a reddish brown with potassium ferrocyanide. Bread is touched at once with the reagent, which produces reddish brown spots; an addition of 550 *mgrm.* per kilogramme or upwards renders the bread remarkable by its greenish colour. Pure flour, according to numerous analyses by French chemists, on an average has 8 *mgrm.* copper per kilogramme; this copper, derived from the plant, does not react with potassium ferrocyanide.

Zinc sulphate is sought for in the ash. See Section XVIII.

For the quantitative determination of zinc and copper the bread is incinerated in a porcelain capsule after it has been well moistened with concentrated sulphuric acid, and dried again upon the sand-bath. The difficult quantitative determination of alumina is best left to a chemical specialist.

Lead and zinc have been introduced into bread by the use of painted or impregnated wood to heat the baker's oven (*e.g.*, Ducamp, *Annal. d'Hygiene*, 1877, Sept.); hitherto, however, no mercury or arsenic has been met with. But arsenic has repeatedly been introduced into dough, from malice or by mistake, and occasioned wholesale poisonings (Paris, Würzburg, Kaiserslautern, &c.).

§ 335. For determining acidity 100 *grm.* of bread, finely comminuted, is introduced into a calibrated roomy beaker with so much hot water that the volume amounts to 400 *cc.*, well stirred up, and allowed to stand for some hours in a cool place. For titration we take two portions each of 100 *cc.*, using one-fourth soda, and as indicator phenolphthaleine. The acid of the bread can be almost completely extracted from the bread with water; free acetic and lactic acid is present only in very small quantities; along with acid potassium phosphate (K. B. Lehmann). I am still engaged with further studies on this subject.

§ 336. On microscopic examination we find in bread chiefly swelled and ruptured starch grains, totally distorted into balls and clots. In order to search for fragments of weeds, &c., I recommend treating about 10 *grm.* of bread

exactly according to the Weender method for determining cellulose (§ 221). From the cellulose obtained pure by decantation, characteristic fragments of weeds may be isolated, especially cockle, ergot, corn-flowers, galium (less easily tares, &c.). I have instituted also quantitative determinations of weeds (cockle) in this manner, determining the surface of the isolated fragments of the seed-husks, and comparing them with the surface of a known weight of cockle-seeds. I have met with loaves containing up to 7·0 per cent. of the dry substance. Isolated fragments of corn-cockle may be weighed.

It has been recently recommended to destroy the starch with strong hydrochloric acid and potassium chlorate, especially also for the microscopic diagnosis of rye and wheat flour. (See Soltsien, *Pharm. Zeitung*, 1889, p. 313.)

The examination for hyphomycetes in bread must also be conducted microscopically, but unfortunately it is little demanded from a hygienic point of view. Examinations of bread by the plate method are still wanting, but might be easily effected with the finely grated material. *Bacillus mesentericus vulgatus* (§ 84) has recently been shown by Kratschmer and Niembwicz to be the cause of a slimy decomposition of bread (*Centralblatt f. Bakteriologie*, vi. 501), and Uffelmann (*Centralblatt f. Bakteriologie*, viii. 482) shows that besides *B. mesentericus vulgatus*, *B. mesentericus liodermus* occasions this decomposition. Loaves which are slightly acid seem subject to this decomposition.

C. Decision Concerning Flour.

§ 337. 1. *Proportion of Moisture and Soundness.*—Flour contains generally from 12 to 14, rarely only from 10 to 12 per cent. of water; the presence of 18 per cent. must be pronounced too great. Such flour has not merely a diminished nutritive value, but it is frequently spoiled, as moisture greatly promotes decomposition. If any suspicious property is detected: a mouldy smell, an irritating taste, an abnormally high number of microbia, a microscopically rich assortment of hyphomycetes, the flour must be pronounced as strongly suspicious of unwholesomeness, as shown in § 341.

A certain criterion for the unwholesomeness of a spoiling flour is unfortunately still wanting, but especially in the summer months much flour which has become heated is still baked. The destructive pellagra of Upper Italy may certainly be traced to spoiled maize. (Compare also Ergot.)

The preservation of flour is still in many cases irrational; the storage in sacks is quite unsuitable; it is recommended in preference to store it on open, airy warehouse floors, frequently turning it over, or to solder up the flour, previously dried at 100°, in metal vessels.

§ 338. 2. *Admixture of Diseased Grain.*—Ergot, according to Kobert, contains, along with the paralysing ergotic acid, sphacelic acid which occasions gangrene, and besides numerous harmless alkaloids, the highly poisonous cornutine, which occasions abortion, muscular cramps, and violent intestinal irritation.

Ergotised bread most frequently brings on chronic poisoning; after its use for five days, though sometimes only after the consumption of such bread for five weeks, symptoms of poisoning have been observed. For the phenomena of the affections which appear sometimes as *Ergotismus gangrœnosus*, and sometimes as *Ergotismus convulsivus*, see medical literature. Even quite recently there have occurred amongst us epidemics (*e.g.*, in Hessen, 1879 to 1880). One part per 1000 of ergot in bread is said to be sufficient to bring on chronic poisoning (certainly ½ to 1 per cent.). A single dose of 4 *grm.* may occasion severe poisoning. Children are particularly susceptible. Small quantities of ergot seem often to occur in badly cleansed grain; of four samples of coarse rye meal from the north-west of Germany which I recently examined all contained ergot, one sample as much as 0·9 per cent. (See Kobert, *Archiv f. Exper. Pathologie*, 1884, and Krysinski, *Pathol. und Krit. Beiträge zur Mutterkornfrage*, Jena, 1888.)

A remarkable fact, too little recognised, is that fresh ergot is in many places eaten by children in the fields as a delicacy in not inconsiderable quantities—it is alleged without any bad consequences; two persons assured me that they had often done it. Poehl expresses the direct view that the action of ergot depends on ptomaines formed in moist ergotised flour. On the other hand, we must remember that the experiments on animals have all been made with pure ergot.

Spores of Ustilagineæ probably occur only scattered. Otherwise poisoning is conceivable in view of the danger that our indigenous Ustilagineæ may act like *Ustilago maydis*. Concerning the latter, there exist along with numerous positive American statements (*e.g.*, Rademacher and Fischer, *Pharm. Journal*, vol. xx. 1887), the account of a contractive action on the uterus, also experiments on ruminants (Brefeld) without any result. Kobert also did not succeed in isolating a poisonous substance from *Ustilago maydis*.

On the other hand, there exist, especially concerning *Tilletia caries*, a series of veterinary observations showing that beasts became seriously ill, or perished after consuming strongly sporiferous meal. (For the bibliography see in Friedberger and Fröhner, *Spec. Pathol. u. Therap. der Thierkrankheiten*, 2nd edition, vol. i. p. 219.) We may readily assume a formation of ptomaines by these fungi. In any case it is advisable for the present to declare flour injurious to health if it contains an abundant proportion of Ustilagineæ without regard to the species. The Uredineæ also on the stalks and leaves are said often to have had an injurious action. (See literature cited above.)

Strongly narcotic symptoms have been observed last year in France consequent upon the consumption of grain covered with abundant fungoid vegetations (Prilleux, *Centralblatt f. Bakteriologie*, x. 200), and Russia (Woronin and Sorokin, *Centralblatt f. Bakteriologie*, x. 231, &c.). Careful botanical examination detected numerous heterogeneous fungi, which are described in detail, though none of them can be definitely regarded as the cause of the toxical action of the grain. Nothing is remarked concerning the seeds of weeds.

§ 339. 3. *Seeds of Weeds.*—Any detection of seeds of weeds in flour or bread to at all a plentiful extent warrants its being regarded as hygienically exceptionable. If a poisonous weed has been detected this decision is a matter of course, but even the recognition of non-poisonous weeds is sufficient, as it proves the flour to have been imperfectly cleansed, and thus betrays the possible presence of poisonous weeds which have hitherto not been detected at all, or at least not with certainty.

From 4 to 5 *grm.* of cockle-seeds baked into white bread are sufficient to produce slighter irritations of the mucous membranes (pharynx, bronchial canal, and stomach). See K. B. Lehmann and Mori, *Arch. f. Hygiene*, ix. Calves are killed by a dose of about 250 *grm.*; all domestic animals, especially the carnivora, suffer from their ingestion, but sheep and rabbits very little. For particulars on the toxicology of the Saponine group see *Arbeiten des Pharmak. Instit. in Dorpat*, parts i. and vi., edited by Kobert.

In northern, and especially in north-western Germany, grain is consumed (from country mills), which in many cases is badly cleansed to an incredible degree. (See §§ 330 to 336.)

Concerning darnel (*Lolium temulentum*) earlier statements are partly contradictory; poultry in general bear it easily. O. Becker (*Arch. f. Pharmacie*, 1872, p. 178) observed in several persons, after partaking of a loaf containing 17 per cent. of darnel, trembling, dizziness, and sweating. Gampf even reports a fatal case (*Jahresbericht f. Pharmacie*, 1878, p. 636); on the contrary, Wilson alleges that he has consumed considerable quantities of the seed of darnel baked up in bread without injury. Antze (*Hyg. Rundschau*, i. 315) has recently isolated from *Lolium* a volatile alkaloid, loliin, and a non-volatile alkaloid, temulentine, and has established their intensely poisonous action on rabbits and men in experiments which are certainly described in a rather inaccurate manner.

Lathyrus Cicera, L. Clymenum, and L. sativus have occasioned in the south very severe affections of the spinal cord (spastic spinal paralysis) if admixed with bread. (See Schuchardt, *Deut. Arch. f. Klin. Med.*, vol. xl. 1887, and J. Ch. Huber, *Friedreich's Blätter*, 1886, p. 34.)

Tares (Vicia) seem non-poisonous; animals bear them perfectly; I am not aware of experiments on men. Among the other leguminous plants occurring among grain, some may possibly be poisonous, *e.g.*, *Ervum ervilia* has a poisonous action upon swine in Greece.

I have personally eaten in large quantities Rhinanthus seeds baked up into bread (twice 10 *grm.* and once 35 *grm.*) without any bad effects, and to beasts they seem harmless (*Arch. f. Hygiene*). Similarly inert were seeds of *Melampyrum arvense* and *sylvaticum* (15 *grm.* of each), which I recently consumed baked up in bread, though certainly only once. The "melampyrism" of the French is very probably caused by another weed. *Delphinium consolida*, Adonis, and probably Ranunculus seeds may also have a poisonous action, as they notoriously contain poisons, but hitherto they have never been recognised as causes of poisoning. Numerous field-weeds have not been examined.

§ 340. 4. *Mineral Components or Additions.*—As soon as rye flour yields more than 2·5 per cent. of ash, or a wheat flour more than 2 per cent. it has not been well prepared (badly cleansed, or ground with bad millstones), or got up fraudulently; more than 0·2 per cent. of sand is inadmissible.

Danger is not occasioned by calcium sulphate, calcium or magnesium carbonate, but it is by relatively small quantities of barium salts soluble in the gastric juice, *e.g.*, barium carbonate. (See Section XVIII.) Whilst an addition of barium carbonate at once renders flour unwholesome the insoluble barium sulphate is harmless. For a fatal case of poisoning by a tart containing 2·74 per cent. of barium carbonate, see *Vierteljah. f. ger. Medicin*, vol. xxviii. 1878. For the presence of lead see Section XVIII.

The addition of copper or zinc sulphates must be objected to from a hygienic point of view.

Concerning the much discussed unwholesomeness of small quantities of these substances compare Section XVIII.; in any case, they have no business in bread, and in Germany at least there is absolutely no ground for their toleration,[1] since they enable the use of inferior flour hygienically suspicious, and an increase of the proportion of water (as likewise does alum) by 6 or 7 per cent. Further, the addition of these substances, where customary, is often practised in so slovenly a manner that we have no guarantee against the incidental presence in bread of doses which are toxicologically serious.

There have been found, *e.g.*, 0·53 *grm.* copper sulphate, and 0·35 *grm.* zinc sulphate per kilogramme of bread. Compare Eulenberg and Vohl (*Vierteljahrschrift f. gericht. Medicin*, 1870, p. 322), and Kuhlmann (*Dingler's Polyt. Journal*, vol. xxxix. p. 439).

Small admixtures of alum may be in themselves hygienically unimportant, but they are objectionable on the same grounds as the presence of copper. In Antwerp there has been recently found in flour as much as 1·12 per cent. of alum, the workman who had to make this addition confessed that he judged the quantity merely by the eye. Two Dutch professors declared from two to five per thousand of alum in bread not injurious; here also experiments are wanted for a certain decision. Generally speaking, flour with an abundant addition of alum is regarded as exciting disturbances in digestion and constipation. See § 490*a*.

D. Decision on Bread.

§ 341. In a special decision on bread, in addition to the points mentioned under flour, the following must be considered:—

[1] Is there such ground in any other country?—*Editor.*

1. The moisture in bread must in no case exceed 40 to 45 per cent. In general the proportion of moisture fluctuates greatly, and is very essential for determining the nutritive and the commercial value of any sample. According to König the average moisture is:—

	Per Cent.		Per Cent.
Rolls	28·6	Rye bread. . . .	42·6
Fine wheat bread . .	35·6	Ammunition bread . .	36·7
Coarse wheat bread . .	40·5	Pumpernickel[1]. . .	43·4

According to Fehling, white bread contains 45 per cent. of moisture, and black bread 48 per cent.

New bread, whilst still hot, is universally regarded as unwholesome, as on mastication it forms lumps not easily pervaded by the gastric juice. As a rule, newly baked bread should not be eaten before the lapse of twenty-four hours. On keeping, ammunition bread loses daily 1 per cent. of its weight by the escape of water; the soldiers do not generally obtain it until it is eight days old.

Bread, after some time, becomes "old," or "stale," not so much by the loss of water as by the transit of moisture from the starch to the gluten. The crust becomes softer, and the crumb drier; by heating (to about 80° internally) the water (a kind of water of hydration) is driven back from the gluten to the starch. Thus is explained the paradoxical fact that dry bread may be rendered "new" again by a short heating. If the proportion of water was below 30 per cent., and if the bread consequently was already several days old, a slight moistening of the surface is previously necessary. Additions of barley, oats, or maize cause the bread quickly to appear dry. An admixture of potato flour yields moist bread. The addition of bran facilitates the fraudulent production of watery bread. Artificially freshened bread, if otherwise not spoiled, cannot be regarded as unwholesome, nor can it be pronounced inferior in value from a hygienic point of view.

It occurs again and again that old remnants of bread, comminuted, are mixed up with new dough to the extent of about 1 per cent. The hygienist must here ask above all things what was the nature of such stale bread; if it consisted of refuse or mouldy fragments, the bread produced will be disgusting, or under certain circumstances even injurious; if it was good although old, no hygienic principle seems to be violated. The practice requires strict suppression, as no distinction is generally made whether the bread thus added was more or less spoiled.

[1] Pumpernickel is a very course rye bread containing much bran. It is chiefly used in Westphalia, and is totally unknown in Britain.—*Editor.*

2. *Thorough Baking.*—Bread which has not been properly fermented, which is watery or not well baked, is difficult of digestion, and for persons of weak digestive organs it may be positively unwholesome. Growths of hyphomycetes occur in such bread in exceptional abundance; resistant spores may survive after imperfect baking, and the proportion of water fosters their growth—as also in good bread which has been kept in a damp place. Bread from flour which has been damp and has had its gluten modified is tenacious of damp, and will have risen badly.

3. *Acidity.*—On titrating dough according to § 335 I found in 100 *grm.* of commercial bread, containing from 30 to 45 per cent. of moisture, very considerable differences, due to the kind of flour used, quite independent of the manner of preparation. Thus, in fine white bread the acidity was generally only from 1 to 2, but rising exceptionally to 5 and 6. Heavy North German coarse rye bread showed an acidity of from 1 or 2 to 17 and 18. From about 110 examinations of bread I have deduced the following names for the degree of acidity (see K. B. Lehmann, *Archiv f. Hygiene*, xvi.):—

Normal Alkali per 100 *grm. of Fresh Crumb of Bread.*

	Name.
1 to 2	Not sour.
2 to 4	Slightly sourish.
4 to 7	Slightly sourish.
7 to 10	Distinctly sour.
10 to 15	Strongly sour.
15 to 20	Very strongly sour.
20 to 25	Extremely sour.

4. Bread from spoiled flour contaminated with organic or inorganic constituents is to be judged like such flour.

5. Mouldy bread has often had injurious effects; it is always disgusting, and tastes unpleasantly. Kowalowsky maintains that he has observed in bread made from mouldy flour a diminution of the albumen at the expense of the other nitrogenous constituents (*Chem. Zeitung Repert.*, 1890, p. 191).

Until it has been demonstrated that certain kinds of mould do not render bread injurious, it must always be regarded as unwholesome.

In view of the low resistance of the moist spores of moulds to heat, we must always assume infection of the bread subsequent to baking, in which flies are occasionally concerned. Payen has indeed asserted that the spores of *Oidium auruntiacum* resist a temperature of 120°.

The most celebrated and most frequently described is a reddish-yellow mould, *Thamnidium aurantiacum* (= *Oidium aurantiacum*), which has often occasioned epidemics in France. The use of such bread, which has a bitter taste and an offensive smell, produced violent thirst; prisoners fed upon it were reduced in health; the transformation products of the microbe seem therefore to be injurious. Feeding with the mould had no effect on the lower animals (Rochard); but Decaisne alleges that he has rendered cats and rabbits ill by feeding with this mould. In 1871 the bread at Paris was in many cases quite uneatable in consequence of the orange mould. Besides and along with *Oidium aurantiacum*, species of Mucor, Rhizopus, Aspergillus, and Penicillium have often been observed upon and in bread. Catarrh of the bowel has not unfrequently been the consequence of the use of such bread, but severe illness seems to have been rarely observed, *e.g.*, Robertson (*Lancet*, September 10, 1887). The *Jahresb. f. Pharmakol.*, &c., 1866, p. 428, report the illness of an entire family after the use of very mouldy bread; the severe illness of three persons, and the death of a girl five years of age from eating mouldy black bread. Brugnatelli and Zenoni assert that they have isolated alkaloids from mouldy maize-bread. For the bibliography of mould-poisonings and figures of the various moulds see Rochard (*Annal. d'Hygiene*, 2nd series, vol. xl. p. 40).

Bacillus prodigiosus renders bread and other starchy substances disagreeable in appearance on account of red spots, but does not seem to form poisonous transformation products. Whether *Bac. mesentericus vulgatus* renders bread unwholesome is not determined, but it unquestionably renders it unpleasant.

§ 342. On the question what bread is best adapted for nutriment, the following points have to be considered:—

1. If it is required to present to a sound stomach the most nutritious bread possible at a low price, a rye bread containing a moderate proportion of bran (about 20 per cent. of the grain must be separated out as bran) which is utilised down to 10 per cent. of the solids is by far the most practical, although 22 per cent. of the nitrogen is lost in the bowel. The moderate acidity which ascends in the bowel, and the moderate proportion of bran, accelerate the peristaltic motion, whence the rather high loss of solids; the nitrogen of the bran is utilised only to two-thirds of its weight, whence the relatively high loss of albumen in the fæces. But such

bread is cheap, agreeable in taste, and does not disagree even in quantity.

2. If the digestive organs are remarkably well developed or accustomed to it, even the heavy groat bread, strongly acid, and made from the whole grain, can be tolerated. On account of its cheapness it forms a good nutriment, in virtue of its high proportion of acid and bran, notwithstanding its imperfect utilisation (the loss of total solids being 19 per cent., that of nitrogen 42 per cent., and of carbohydrates 10 per cent.).

According to Uffelmann this would be in fact the cheapest form of nourishment with bread. G. Meyer finds the utilisation so imperfect that, according to his experiments, nutrition with the more expensive fine rye bread (or medium fine bread) would be cheaper. Rubner also finds it economically more correct to eliminate a part of the bran and to use it as cattle food. Wicke has recently again shown in Rubner's laboratory that a decortication which removes 5 per cent. of the grain raises the utilisation from 79 to 87 per cent., and therefore involves a direct advantage (*Archiv f. Hygiene*, xi. and xii.).

3. If, on the contrary, a bread-nutrition is to be selected which burdens the stomach as little as possible, and is as little voluminous as is practicable, fine white bread, especially rolls, must be preferred, as of them only 5 per cent. of the total solids, 20 per cent. of the nitrogen, and 1 per cent. of the carbohydrates reappear in the fæces. In spite of the good utilisation, the kilogramme of absorbed albumen and carbohydrates in the form of white bread is more expensive than in other sorts of bread.[1]

APPENDIX I. — PREPARATIONS OF FLOUR, ADDITIONS FOR SOUPS, MACCARONI, LEGUMENS, AND LEGUMINOUS MEALS.

§ 343. All these numerous preparations are examined and judged on the same principles as flour in its ordinary sense. Table IX. gives some analyses. *Panir meal* consists of the slightly roasted remnants of bread from inns, disguised by

[1] Only those portions of the above paragraphs which relate to white (*i.e.*, wheaten) bread have any direct interest for the English reader.—*Editor.*

grinding; it is therefore a preparation doubtfully appetising, and is generally coloured.[1]

In preparations of leguminous seeds the degree of comminution is important; a microscopic examination easily shows how far the several cells are untouched or crushed. The finest products of this kind scarcely contain any unbroken cells.

On the dextrination of starch see § 220.

Strikingly yellow colorations of vermicelli, the object of which is to simulate the use of eggs, are to be examined and decided on according to Section XVIII.

APPENDIX II.—THE MOST IMPORTANT KINDS OF STARCH.

§ 344. Starch is obtained industrially by elutriating the ground materials with water. Starch should be free from ash, pure white, dry, free from the spores of moulds, of a pure smell and taste. On its composition see Table IX.

In view of the extensive application which starch experiences (that of wheat, of potatoes, maize, rice, and some exotic plants) as an article of food, a tabular conspectus of the most important kinds is here given. The differential diagnosis depends on microscopic characters, and is without hygienic importance, as all kinds of starch agree probably in their chemical composition, and are equally utilisable and wholesome. Foreign sorts, though without any hygienic ground, have a higher commercial value, and are especially prized for the food of children. Of native starches, potato-starch (often named potato-flour, or swelled and moulded as German sago) and wheat-starch (under all possible names, and also as a powder) are principally met with in trade; maize-starch is sold as maizena and mondamine, &c.;[2] rice-starch is the most expensive. The following conspectus shows the most important starches and their names, according to Möller:—

[1] Panir meal is not a known article of commerce in England.

[2] In England maize-starch figures as "corn-flour."—*Editor.*

West Indian or Jamaica arrowroot, sometimes known as African, Indian, or Brazilian arrowroot	*Maranta arundinacea*, and some other *Cannaceæ*.
Indian arrowroot, tick meal . . .	*Curcuma angustifolia*, &c.
Queensland and Indian arrowroot . .	*Canna indica, edulis*, &c.
Brazilian arrowroot	*Manihot utilissima.*
Cassava-flour, genuine tapioca . . .	
Brazilian arrowroot	*Batatas edulis.*
Batata starch	
Guayana arrowroot	*Dioscorea sativa.*

The above are obtained from tubers.

Guayana arrowroot	*Musa paradisiaca.*
Banana starch, Pisang starch . . .	

The last-mentioned sorts are from fruits and seeds.

Genuine sago	Species of *Sagus, Arenga borassus, Cycas, Zamia*, &c.

From stems.[1]

Table for the Determination of the most Important Starches.[2]

(In part according to Möller.)

§ 345. I. All or nearly all the starch-grains are single, not compound.

a. Grains roundish, lumpy, or lenticular; stratification exists at most only at the margin.

1. Along with large roundish grains, the stratification of which is barely indicated, there are small globular or angular fragmentary grains; intermediate forms between these two kinds cannot be detected with certainty. *Wheat, Rye, Barley.*

These sorts of starch cannot be distinguished with certainty without taking into account the form of fragments of the pericarp which may possibly be present. We have to consider:

1. For wheat: Nuclear splits in the large grains not very frequent. Majority of the large grains roundish and from 20 to 30 μ in diameter, the largest 50 μ. *Wheat.*
2. For rye: In the large grains cross clefts are very common. Along with the large roundish grains there are also crooked forms. The majority of the large grains are from 30 to 35 μ in diameter, the largest 50 μ. *Rye.*

[1] It will be seen that the nomenclature of the starches is very confused.—*Editor.*

[2] For quantitative determination of potato, wheat, and rye starch the use of a polarising microscope is recommended. The potato-starch grains appear much lighter; the percentage of the two kinds of grain may be found by counting. (*Chem. Zeitung*, 1890, p. 1605.)

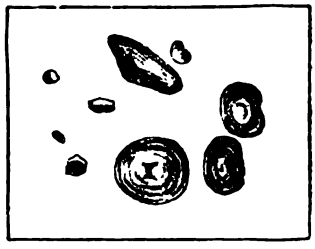

FIG. 105.—Wheat.

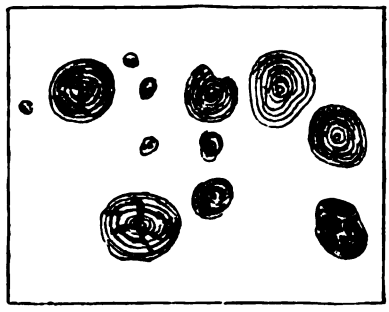

FIG. 106.—Wheat from Sprouted Grains.

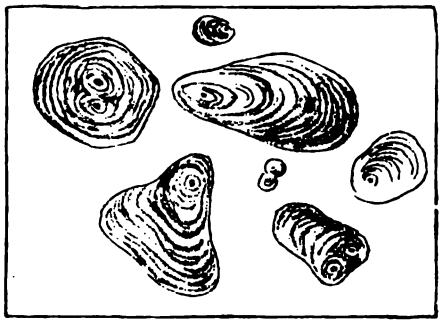

FIG. 107.—Potato.

FIG. 108.—Lentil.

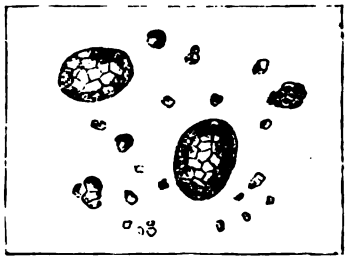

FIG. 109.—Rice.

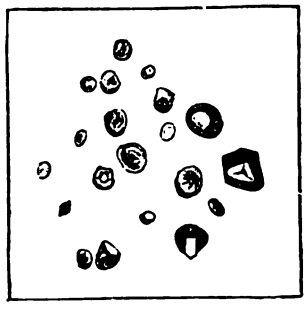

FIG. 110.—Maize.

FIGS. 105 to 110.—Starch Grains according to Möller (magnified 300 diameters).

3. For barley: Very like wheat-starch, but bean-shaped and irregular lumpy forms are rather more common. The large grains are generally from 20 to 30 μ, not above 35 μ in diameter. *Barley.*

b. The grains have all indistinctly crystalline surfaces, sharp edged, with a nuclear cleft, but not stratified. The angular grains are in reality parts of larger aggregations. Diameter 20 μ. *Maize.*

c. Grains simple, roundish egg-shaped, with pronounced stratification.

1. Many grains above 50 μ in diameter.

a. Most grains egg-, shell-, or hatchet-shaped, single falsely connected grains. Nucleus chiefly at the pointed end. *Potato.*

β. Numerous grains, more than 100 μ, shield-shaped; nucleus at the broad end, partly emarginate and partly drawn out to a point. No compound grains.

2. No grains above 50 μ.

a. Grains flat, rod-shaped on a side view.

1. Grains drawn out into a short point at the narrow end, near the nucleus. *Curcuma.*

2. Grains sharpened like a wedge at the broad end, otherwise similar. *Dioscorea.*

3. Very similar, but more sausage-shaped. *Banana.*

β. Grains not flat, tuberous, rounded.

1. The large grains are chiefly bean- or kidney-shaped, distinctly stratified at the margin, and show a nuclear fissure running in the longitudinal axis, with numerous cross fissures. The small grains are rounded or longish (beans, lentils, peas, tares). *Legumens.*

2. The starch from mature wheat or rye is similar; but here, along with the stratification, the gnawed appearance of the margin and the occurrence of radiating clefts are striking. *Wheat and rye* (from mature grain).

3. Grains of a rather irregular form, and with very distinct stratification around a nucleus situated centrally or near the obtuse end. *Maranta.*

II. Grains mostly compound or having many surfaces, *i.e.*, sharply defined, rectilinear surfaces may be seen on the rounded grain.

a. Grains composed of numerous (as many as 100 and upwards) small angular granules. The aggregates may reach 60 μ in size, the granules 6 to 8 μ, or at most 10 μ.

1. There are only the above-described forms, with sharply angular granules. *Rice.*

2. There are also small rounded or spindle-shaped granules. *Oats.*

b. Granules roundish, polygonal, united into small aggregations. *Buckwheat.*

c. Compound grains very scanty; the granules mostly isolated, angular, large (up to 35 μ). Nucleus and nuclear fissure generally distinct. *Maize.*

d. Starch grains composed only of two to four granules, which are partially (often mostly) broken.

1. Some few small granules with flat planes often adhere to a large, roundish main grain (30 to 80 μ), or they may have fallen off. Stratification distinct around an excentric, often split. *Sago.*
2. The parts of a compound grain almost equal in size, twin forms most frequent.

a. Many broken grains, drum-shaped, rarely exceeding 20 μ; a central nuclear hollow, stratification indistinct. *Manihot.*

β. Fractional grains, of the shape of a sugar-loaf, in size as much as 50 μ. Stratification around an excentric nucleus. *Batatas* (sweet potato).

The fact that many starches, to give them the appearance of a purer white, have received the addition of a blue colour, is hygienically of no importance, as the dye-wares employed (ultramarine, prussian blue, or smalt) are quite harmless in the proportions present.

APPENDIX III.—A FEW HINTS ON FOODS FOR CHILDREN.

§ 346. The numberless preparations for the artificial nourishment of children may be divided into (1) preparations of finely ground cereals or leguminous seeds; (2) preparations in which the starch is partially converted into dextrine; (3) preparations more or less dextrinised, to which condensed milk, often strongly sweetened, has been added.

The examination is conducted according to the methods given for flour and milk; the determination of the various carbohydrates simultaneously present must be regarded as of exceptional importance (see § 221). Particulars both as to their composition and examination may be found in König (*Chemie der menschlich. Nahrungs- und Genussmittel*).

The physiological decision does not lie within the scope of the present work. See Munk and Uffelmann, *Ernährung des gesund. und krank. Menschen*, 2nd edit., Vienna and Leipzig, 1891. Moreover, foods for children must most strictly conform to the principal demands laid down for flour and milk.

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SECTION X.

VEGETABLES, POTATOES, FRUIT, AND THEIR PREPARATIONS.

1. Potatoes.

§ 347. Sound, ripe, *i.e.*, fully matured potatoes form one of the most important popular foods.

A chemical analysis (see Table IX.) is scarcely ever necessary on hygienic grounds; if required, we must cut discs from the peeled potatoes, of which about 200 *grm.*, accurately weighed, are strung on a thread and dried at about 30°; they are then ground finely (say in a new coffee-mill); the air-dried meal is weighed and examined exactly like the flour of wheat.

Within a limit of error of about 1 per cent. the proportion of starch and the total solids may be read off from the specific gravity by means of the following table.

The determination is carried out as follows:—

Over a capacious cylinder of glass there is laid a metal rod, from which a point projects downwards towards the level of the water. When the water touches this point the cylinder contains, *e.g.*, 2 litres of water. We then weigh off 1 *kilo* of cleansed dried potatoes and place them in the empty vessel: 1 litre of water is then added, and more water is allowed to flow in from a burette until its level exactly touches the point (*e.g.*, 120 *cc.*). If there are altogether 1120 *cc.* of water in the vessel along with the potatoes, then:

2000 − 1120 = 880 *cc.* is the volume, and 1000 : 880 = 1·136 the specific gravity; therefore, according to the following table, the total solids amount to 31·7 per cent., and the starch to 25·9 per cent.

DETERMINATION OF THE TOTAL SOLIDS AND THE STARCH FROM THE SPECIFIC GRAVITY (MÄRKER).

Specific Gravity.	Total Solids.	Starch.	Specific Gravity.	Total Solids.	Starch.
1·080	19·7	13·9	1·125	29·3	23·5
1·085	20·7	14·9	1·130	30·4	24·6
1·090	21·8	16·0	1·135	31·5	25·7
1·095	22·9	17·1	1·140	32·5	26·7
1·100	24·0	18·2	1·145	33·6	27·8
1·105	25·0	19·2	1·150	34·7	28·9
1·110	26·1	20·3	1·155	35·8	30·0
1·115	27·2	21·4	1·159	36·6	30·8
1·120	28·3	22·5			

This method gives available values only for sound, ripe potatoes. As long as no trace of sprouts appears in the depressions of the potato-tubers they are, according to Nowak, to be considered as immature.

Young, unripe potatoes (especially, it is said, when they have grown upon a heavy soil), and also potatoes which have been kept too long and are sprouting, contain solanine, especially in the skin and in the shoots. Ripe potatoes which have reached their full size are either very poor in solanine or totally free from this alkaloid.

Haaf found in 1 *kilo.* of germinated potatoes freed from the sprouts 0·32 *grm.*, in the same when peeled 0·24 *grm.*, in 1 *kilo.* of unripe potatoes 0·42 *grm.*, and in unripe potatoes peeled 0·32 *grm.* solanine (*Schweiz. Wochensch. f. Pharmacie*, 1864.)

The rather frequently observed injuries to health, especially from the use of young potatoes, is often ascribed to solanine, but such potatoes are difficult to digest, on account of the high proportion of water and the small percentage of starch (see Fruit). The poisonous character of solanine in potatoes is at least exaggerated; the diseases of cattle ascribed to the consumption of solaniferous potato-waste (distillery waste) have been partly infectious diseases and in part poisonings with ptomaines. Potatoes are further said to lose the chief part of their solanine by boiling. For the bibliography of works, &c., on solanine, see Perles' *Arch. f. exper. Pathol.*, vol. xxv.

On keeping, there ensues in the potato a slow decrease of the starch, which passes temporarily into dextrine, and in small quantities into sugar. If potatoes are preserved in a very cold place, the consumption of sugar is arrested more than the formation of sugar, and the tubers become therefore unpleasantly sweetish.[1] If they are then removed to a room not artificially heated, the sugar is destroyed, and the taste becomes normal again. Frozen potatoes are often destroyed by putrefaction after thawing, but before they putrefy they are not hurtful to health. Tubers bared of soil become dark-coloured next the stem; their pungent taste is said to be due to solanine.

The potato-disease (occasioned by *Peronospora infestans*) attacks both the leaves and the tubers; the latter are destroyed partly by dry and partly by wet decomposition, when various moulds and certainly schizomycetes establish themselves as saprophytes. E. Kramer recently described a bacillus nearly allied to Hueppe's *Bacillus butyricus* as the cause of the wet-rot in potatoes. If the spoiled parts are cut away, the remainder may be eaten without injury; the decayed part tastes and smells so badly that no one will consume it.

2. Vegetables and Fruit in the Fresh and Dried State.

348. Vegetables scarcely require a hygienic examination; if they have become too old and woody they are inferior in value, poor in nutritive matter, and are imperfectly utilised; stale vegetables are inferior in value, and not appetising. If vegetables are watered with cesspool drainage containing the ova of *Tænia solium*, the latter may find their way into man, and grow up to cysticerci; pathogenic bacteria may possibly be introduced by vegetables which have not been purified. An investigation in this direction is much required. The immigration into the interior of plants of bacteria

[1] The sweet potato = batata (*Batatas edulis*), used in tropical countries instead of the potato, contains from 1½ to 2 per cent. of cane sugar.

pathogenic for man (*e.g.*, typhus bacilli into turnips) seems impossible, according to recent researches.

According to Lominsky (*Centralblatt f. Bakteriologie*, viii. 325), various bacteria penetrate into the roots of young plants, but do not increase in them. Several pathogenic species, if inoculated into living leaves, are said not merely to maintain themselves, but even to multiply. A verification of these observations is desirable.

Very remarkable are the observations of De Loos (*Jahresberichte f. Pharmak.*, 1877, p. 536), according to which sometimes vegetables from a plumbiferous soil (situation of some disused white-lead works) take up very considerable quantities of lead. Thus, 650 *grm.* of turnips had absorbed 10 *mgrm.* of lead, six carrots (272 *grm.*) 17 *mgrm.*; four endives, it is alleged, had taken up even 130 *mgrm.* It may oftener happen that plumbiferous dust adheres to plants.

Mistakes of *Aethusa cynapium* (fool's parsley) for parsley, *Cicuta virosa* (water-hemlock) for celery, *Oenanthe crocata* for carrots, &c., are not rare. Cases of poisoning occasioned in this manner have been repeatedly observed.

Sauerkraut produced from white cabbage by lactic fermentation contains 91 per cent. water and from 1 to 1½ per cent. lactic acid (E. Reichardt, *Chem. Zeitung Rep.*, 1891, p. 96).

Dried vegetables are now produced of excellent quality, and, when properly prepared, taste as if fresh. New methods do not come into question in hygienic examinations.

§ 349. Concerning fruit there exist to my knowledge no recent hygienic researches. Unripe fruit, rich in cellulose, acids, and in tannin, and poor in sugar, occasions catarrh of the stomach and bowel. As criteria of ripeness the popular characteristics suffice for an experienced observer.

For stone fruit and berries, the colour, consistence, and taste must be examined, for seed fruits[1] it is necessary to examine whether the pips have taken a brown colour. For carriage (*e.g.*, to England) it is necessary to despatch fruit before full ripeness, and allow it to ripen out in an airy situation.

A severe case of poisoning by twenty-five (!) unripe pears is reported in the *Vienna Med. Presse*, 1886, No. 34. The poisoning in which nervous disturbances (cramp, and loss of speech for six days), predomi-

[1] "Seed fruits," in contradistinction to stone fruit, are apples, pears, &c.

nated over the gastric symptoms, was referred to prussic acid from the pippins. Prussic acid poisonings by peach-kernels, bitter almonds, &c., are known to have been observed not unfrequently.

Mouldy fruit must be judged as in § 341. A severe poisoning of a mother with her child by mouldy cherries (the mould is said to have been *Cladosporium herbarum*), with the symptoms of European cholera, was observed by Bondier. Many persons are said to take mouldy cherries intentionally as a gentle laxative.

Dried fruit, dried southern fruits, are to be examined for dirt (sand, &c.), for mould and mites. The latter are rarely entirely absent. A decision is come to as above; numerous mites render the fruit disgusting. In American dried fruit a proportion of zinc has latterly been detected in several cases.

§ 349*a*. Among the fruit juices raspberry juice especially plays a prominent part. Currant and cherry juice are of less interest. The attempt is made to obtain the juices from the pressed and sweetened fruits in a permanent state partly by boiling and partly by fermentation. Salicylic acid and other preservative agents appear perfectly unnecessary. The pure juice of cranberries contains 0·64 to 0·76 per cent. of benzoic acid (Mach and Portele).[1] As the colour occasionally suffers by unsuitable preparation or preservation, it is artificially heightened with the vegetable colours (infusion of field-poppy flowers). See Lecco, *Rev. Internationale des Falsifications*, 1890, p. 117, or more commonly with tar colours. If the customary red coal-tar colours are used in the small quantity necessary, and if they are free from arsenic and other impurities, then, as it will be explained in § 494, no objection can be raised from a hygienic toxicological point of view. For the detection of these colours we may use the methods given in § 399. For metals see § 460.

3. Vegetables and Fruit Preserved in Boxes.

Preserved vegetables are partly sterilised by heat alone without any additions, the closed vessels (tins, &c.) being

[1] The European cranberry, *preisselbeere*.—*Editor*.

heated in a water- or a lime-bath, or they are converted by the plentiful addition of sugar, sometimes of vinegar or antiseptics, &c., into such bad nutrient media that when they are well boiled, poured into clean glasses and tied up, they require no further heating to be permanent.

§ 350. We are here concerned merely with the examination.

1. *For Soundness.* — Every indication of fermentation (bubbles of carbonic acid) or alteration of taste necessitates caution in forming an opinion; after a repeated boiling such preparations are almost always safe if they have been kept in glass or earthenware, but they are always to be suspected if metal boxes have been used. The acids formed during fermentation facilitate the solution of poisonous metals. Preserves in a state of incipient putridity, *i.e.*, ill-smelling preserves, are probably injurious in consequence of the formation of ptomaines. A layer of mould, which can easily be removed, may generally be regarded as harmless to health if the taste of the preserve[1] has undergone no change.

2. For metallic poisons (copper, lead, tin, zinc) see Section XVIII. A question continually discussed, especially in France, is the unwholesomeness of preserved vegetables to which a bright green colour has been imparted by salts of copper. Traces of copper are very prevalent in uncoloured vegetables; in such as have been stained Gautier found a mean of 90 *mgrm.* per kilogramme, but as much as 150 and 200 *mgrm.* of copper have been found in peas which, according to Brouardel, did not betray themselves by any unusual taste. Cronquist found at Stockholm as much as 0·2 *grm.* For a decision on such additions see Section XVIII. They are in any case unnecessary, as the public would rapidly become accustomed to yellowish green vegetables of the natural colour.[2]

[1] The German word, *konserve*, includes preserves, pickles, and preserved meats.—*Editor.*

[2] It has been suggested in France that whilst the addition of copper to vegetables for exportation might be sanctioned, it should be strictly suppressed in such as are for home consumption.—*Editor.*

Tins for preserves have often been the means of introducing into preserved vegetables appreciable quantities of lead and tin.

Gautier states the average proportion of lead in tinned vegetables as 2·5 *mgrm.* per kilogramme. He found animal substances preserved in oil much richer in lead; in sardines, lobsters, &c., preserved in oil, he found from 10 to 50 *mgrm.* per kilogramme; the oil from the preserved meats was often still richer in lead.

Ungar and Bodländer (*Ergänzungsheft zum Centralblatt f. Gesundheitspflege*, vol. i.) detected from 200 to 400 *mgrm.* tin per kilogramme in vegetables and fruits which had been preserved in boxes of tinned iron. Blarez obtained similar results (*Journal de Pharmacie et de Chemie*, 1890, part 4). Ungar and Bodländer even seek in one case to refer a case of acute illness in a human subject to the presence of tin in preserved fruit. See § 487.

Tinned tomatoes often occasion poisoning in England and America, where they are in request; the cases are referred to metals (lead and tin). An organic acid in the fruits effects the solution of the hurtful metals.

3. For preservative agents (see § 228). Brand found enormous quantities of SO_2, as much as 1·57 *grm.* per litre, in tinned vegetables, especially asparagus. In other samples there was found 0·34 per cent. of SO_3, where the sulphurous acid had therefore been already oxidised. (*Bayr. Industrie u. Gewerbsblatt*, N. F. 1889, 21, 703; *Chem. Zeit. Rep.*, 1889, p. 349.

4. For the nutritive value of such preserved foods, for the proportion in which they are utilised in the human system, and for their worth at the price, see § 222.

4. Mushrooms.

§ 351. The examination of the fungi fit for consumption must be effected according to one of the special works cited below, accompanied with coloured figures. Whoever has not made a thorough study of these plants should confine himself

to the consumption of five or six common species not likely to be mistaken for others. Even the fungologist ventures to eat, relatively speaking, few species.

There are no general characters for the recognition of edible fungi; thus, *e.g.*, the dreaded blue coloration of a broken part occurs also in certain wholesome species; an unpleasant smell of a fresh mushroom is no more proof of poisonous properties than a pleasant smell and taste are of the contrary, &c.

It must be noted that the virulence of many (of all?) poisonous fungi varies enormously according to the year and the locality; *e.g.*, *Amanita phalloides*, from one and the same locality near Berne, was in two successive years very poisonous and almost harmless; *Boletus luridus* yielded, according to Böhm, in four successive seasons smaller and smaller proportions of muscarine; species of agaric were very often eaten in the neighbourhood of Munich, when they suddenly became at once poisonous. Exactly those fungi which are at times harmless demand the most numerous sacrifices, as it is customary in many places to eat them without hesitation, it is natural that, along with the fluctuating poisonousness of one and the same species, cases of poisoning may often arise from confounding poisonous with harmless species.

It is a matter of course that even of the kinds known as wholesome only such specimens must be gathered as are fresh, not corroded, decayed, or damaged by rain, and the mushrooms must be carefully cleansed before use. It is not advisable to preserve portions of dishes of mushrooms which have not been consumed. The use of dried mushrooms is as far as possible to be avoided; they are, according to Bischoff, seldom correctly determined, often imperfectly cleansed, often preserved in an unappetising manner, dusty and perforated by insects. The superior preserved mushrooms of commerce kept in glasses fulfil all conditions, and must be judged like preserved vegetables.

In Berlin the dried morels consist only to a small extent of the dried *Morchella esculenta* (according to Bischoff); many samples contained chiefly poisonous species of Helvella, and in consequence occasion

frequent poisoning cases. The dried mushrooms were found by the same author composed of various harmless kinds of Boletus. The poisonous *Scleroderma aurantiacum* was once found instead of truffles. These confusions or substitutions would evidently prove often more serious in their results if many fungi did not lose their virulence on drying, especially *Helvella esculenta*.

The theory of nutrition at present takes a view opposite to that formerly held as far as the fungi are concerned, *i.e.*, that in spite of the high percentage of nitrogen in their solids they do not rank higher in nutritive value than the majority of vegetables. Like the latter they yield an edible food only in presence of much water, their proportion of nitrogen is largely referable to worthless amido-compounds, the utilisation of their albumen is very imperfect. Like the majority of green vegetables, they contribute more to enjoyment than to nutrition. (For details see the works below mentioned, especially that by Uffelmann.)

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SECTION XI.

SUGAR, HONEY, SACCHARINE.

1. Sugar and Honey.

§ 352. For domestic purposes the sweetening ingredient almost exclusively used is saccharose, obtained from the sugar-cane or from beets. The crystalline products met with in the form of loaves or cubes scarcely require any hygienic examination, as they consist approximately of pure cane-sugar. Farina-sugar, powdered sugar, &c., are said to be occasionally falsified with other white powders, as flour (see § 327).

The ash is determined with small quantities of pulverised sugar; further quantities are not added until the former portions are completely incinerated. It is recommended to add to the sugar a little vaseline, containing no ash, as the combustion is thus rendered much more tranquil.

The recent proposal to ignite 5 *grm.* powdered sugar in a platinum capsule along with 5 to 7 *grm.* of coarsely powdered quartz sand yields excellent results (Alberti and Hempel, *Chem. Zeitung Rep.*, 1891, p. 227).

A proportion of inverted sugar (§ 220) occasionally met with in cane-sugar, and falsifications of crude cane-sugar with the less sweet grape-sugar, do not concern hygiene. Reasons for this will follow. A detection or a determination of these sugars, which reduce Fehling's solution, is easily effected in presence of cane-sugar as directed in § 221.

Grape-sugar from grapes is scarcely met with in trade as an article of food. But artificial grape-sugar (so-called starch-sugar or potato-sugar) plays an important part.[1] Starch-

[1] Would it not be better to confine the name grape-sugar to the natural product from grapes, and to call the artificial product exclusively starch-sugar, potato-sugar, or glucose?—*Editor.*

sugar is obtained by boiling starch with diluted sulphuric acid.

After the sulphuric acid has been removed by means of calcium carbonate and the liquid decolorised with animal charcoal, the solution obtained is evaporated down. A moderately pure starch-sugar separates out in crystals on slow cooling; the ordinary qualities are obtained by strong evaporation, and are rich in maltose and dextrine-like substances. Sieben found, *e.g.*, 20·1 per cent. of water, 21·7 glucose, 15·8 maltose, 41·96 dextrine, and 0·3 per cent. of ash. This examination is made difficult by the fact that the dextrines are neither absolutely incapable of fermentation (though they ferment only with difficulty), nor are they quite incapable of reducing solution of copper. See remark at the conclusion of this section.

Starch-sugar (of a faint sweetish taste) is used partly as a syrup for a cheap sweetening agent in food, partly it serves (or served) as an addition to wine or to must, as a substitute for honey, for glazing coffee-beans, &c.

On the alleged unwholesomeness of impure glucose, rich in non-fermentable dextrinoid substances, see Wine.

§ 353. Pure honey (bees') has, according to Sieben, an average composition of 34·7 dextrose, 39·2 levulose, 1·1 saccharose, 20 water, and 5 non-sugar. Its appearance (clear or rendered turbid by crystalline granulation), colour, and aroma vary rather considerably according to its origin and composition. "Virgin honey" is the finest quality obtained in May and June, and caused to flow out of the comb spontaneously by the heat of the sun. Centrifugal honey is obtained by "whizzing" the comb; the ordinary sorts are melted out of the comb.

In sixty genuine samples of honey the invert-sugar fluctuated from 68 to 79 per cent., the proportions of dextrose to levulose varied also (limits: 57 per cent. dextrose to 43 levulose, and 32 dextrose to 68 levulose). Cane-sugar was entirely absent in twenty-seven cases, but rose in some cases to 8 per cent.;[1] the moisture ranged from 16 to 25 per cent.; the non-sugar varies from 1·3 to 8·8 per cent. (Sieben).

[1] Had the bees obtained cane-sugar from adjacent sugar-works, a case which has happened? The bees, however, distinguish between cane-sugar and beet-sugar, eschewing the latter if the former is accessible. — *Editor.*

In genuine honey non-fermentable carbohydrates, or such as after *careful* (§ 220) inversion did not reduce copper solutions, are always absent. The non-sugar consists of albuminous substances—wax, pollen, acids (always a little free formic acid), and salts.

In Switzerland honey is sold in quantity by all possible names, mixed with syrup of starch-sugar. These products strike the connoisseur at once by their want of fine aroma and taste. The chemical detection is based upon the sparingly fermentable dextrines in starch-sugars. To ascertain if a honey is genuine we proceed as follows, according to Sieben: 25 *grm.* of honey in 180 *cc.* of water are mixed with 12 *grm.* of press-yeast, free from starch, and allowed to ferment for two days at the temperature of a dwelling-room; the liquid is clarified with aluminium hydroxide, and the residual liquid is filtered. It must be:

1. Perfectly inactive with polarised light.
2. It must not reduce Fehling's liquid, even if it has been heated with hydrochloric acid, as in saccharifying starch or dextrine (§ 220).

In the opposite case syrup of starch-sugar is present.

If we do not employ press-yeast, as did Sieben, but the rather less powerful beer-yeast or even wine-yeast, we find that the sparingly fermentable carbohydrates of the dextrine group may occur even in genuine honey to the extent of 6 to 9 per cent. But these dextrines are more readily fermentable than the so-called "gallisine" in impure starch-sugar, though the latter disappears on sufficiently continued fermentation, with press-yeast which is often renewed.

Compare § 396 and Amthor (*Berichte d. 6 Vers. Bayer. Chem. in Munchen*, 188?, and *Zeit. f. Ang. Chem.*, 1889); Von Raumer (*Zeit. f. Ang. Chem.*, 1889 and 1890, and 9 *Versamm. Bayer. Chem. in Erlangen*, 1890); and, lastly, Mader (*Arch. f. Hygiene*, x. 399).

The quantitative determination of dextrine is effected according to the principles laid down in § 220.

An addition of starch is revealed by the microscope (in pure honey there should be no figured elements except pollen); an addition of mineral powders is detected on determining the ash; pure honey contains only from 0·2 to 0·3 per cent. of ash; possible addition of gelatine is shown

by a solution of tannin, which in genuine honey produces merely tender flocks, but such as has been adulterated with gelatine a dense precipitate.

These sophistications are not injurious to health, and must be judged according to the principles laid down in § 364. Compare Wine.

Langelütje Sugar-honey.—Recently, according to Weigle, there is met with a product composed of invert-sugar, water, very small quantities of mineral matters and free acids, which can be distinguished from genuine honey neither chemically, physically, nor by taste, and is consequently a complete substitute[1] (*Chem. Zeitung*, xv. 1891, and *Chem. Zeitung Rep.*, 1891, p. 146).

Poisonous honey rarely occurs in Europe; H. Wagner mentions poisonous honey collected by humble bees from aconite flowers. The honey of Trebizonde is poisonous from the presence of andromedo-toxine (Plügge), derived from azalea blossoms. Species of kalmia, andromeda, rhododendron, and azalea render the honey of New Jersey poisonous (Tresh). Numerous other species of ericaceæ contain the same poison; our erica, calluna, rhododendron, and ledum do not. For details on andromedo-toxine see De Zaayer, *Pflüger's Archiv*, vol. xl. The poison is soluble in alcohol, insoluble in ether and chloroform, white, crystalline, non-nitrogenous, and excites violent vomiting.

For this section compare E. Sieben, *Ueber die Zusammensetzung des Stärkezuckersyrups, des Honigs und die Verfälschung des Letzteren; Zeit. des Vereins f. d. Rübenzuckerindustrie des Deutschen Reiches*, 1884, p. 837. This distinguished work adduces many auxiliaries for the examination of sugar mixture (especially dextrose along with maltose, dextrose with levulose), and numerous citations. It is not practicable here to enter more closely into these researches, which require an experienced chemist, and which are hygienically only of subordinate interest.

[1] We should protest against the sale of this product except under a special name, and with a distinct declaration of its artificial character.—*Editor.*

2. Saccharine.

§ 354. Latterly saccharine

(orthobenzöic sulphinid, $C_6H_4\langle\begin{matrix}CO\\SO_2\end{matrix}\rangle NH_2$)[1]

has appeared in trade as a white inodorous powder three hundred times as sweet as cane-sugar. It is sparingly soluble (1 : 260), reaction slightly acid; an alkaline salt has been recently introduced as "easily soluble saccharine." Its taste is slightly aromatic, and its after-taste irritating only when the powder itself, or a concentrated solution, is tasted; dilute solutions have a purely sweet flavour. It is partly recommended as a substitute for cane-sugar in certain cases, *e.g.*, for champagne, chocolate, &c., and for diabetic patients as a substitute for sugar in general.

As 2 *grm.* saccharine suffice to give 1 *kilo.* of starch-sugar the same sweetening power as that of 1 *kilo.* cane-sugar, it is likely that substitutions of a cheaper for a more expensive material will be attempted in this direction.

The detection of saccharine is effected by extracting the dried substance with anhydrous ether; if the evaporated residue has a sweet taste saccharine is present, all sugars and also glycerine being insoluble in ether. Ch. Schmitt (*Rep. d. Anal. Chem.*, 1887, p. 438) has given a chemical test, founded on the conversion of saccharine into salicylic acid.

According to the researches of Immerheiser (*Versamml. der Bayer. Chem. in Erlangen*, 1890), a slight proportion of salicylic acid is present in many pure wines, whereby the value of this test is rendered questionable.

The method most recommended at present is that of Weigle-Hilger: the substance dried up upon sand is exhausted with ether + petroleum ether (â). The residue, after evaporating off the ether, is dissolved in slightly alkaline water, freed from any powder of sulphur and drops of ethereal sulphurated oil by passing through a moist filter, mixed with soda and evaporated to dryness, and introduced into melting saltpetre. Thus sulphuric acid is obtained from the sulphur of the saccharine,

[1] According to E. Salkowski the older samples of this preparation are contaminated with 60 per cent., and in the more recent with 30 per cent. para-sulphamine benzoic acid, which does not affect the subjoined remarks, as they refer to samples made in the summer of 1889.

which is precipitated with $BaCl_2$, and weighed as in § 176, 1 *mgrm.* $BaSO_4$ = 0·78 *mgrm.* saccharine.

The decision on saccharine from a hygienic point of view is given by F. Jessen and K. B. Lehmann (*Arch. f. Hygiene*, x.), according to their own experiments, as follows:—

1. Saccharine is, according to the experiments of all authors, non-poisonous; neither single enormous doses (5 *grm.* to a strong man), nor the daily ingestion for three months of 0·1 or 0·2 *grm.* saccharine (corresponding in sweetening power to from 30 to 60 *grm.* of sugar), produced in five men, two boys, and two girls any symptom of disturbed health.

2. The utilisation of milk in man is not affected. The action of saliva upon starch is not affected by easily soluble saccharine; the peptonisation of albumen in artificial digestive experiments is slightly retarded. Experiments on the lower animals (Ogata) proved that in dogs sugar retards the digestion of albumen.

3. The substitution of saccharine for a carbohydrate reduces nutritive value, since saccharine has no nutritive value at all. A substitution of pure starch-sugar sweetened up with saccharine for an equal weight of cane-sugar cannot be regarded, physiologically speaking, as an injury.

4. For the diabetic patients saccharine affords the possibility of an agreeable variety in the taste of their food; the substitution of saccharine for sugar in champagne may be not unwelcome (?) to lovers of sweet champagne, as a large proportion of sugar often affects digestion unfavourably. The antiseptic and antizymotic properties of saccharine have no practical value.

5. If the use of saccharine is thus hygienically unobjectionable a declaration of its presence should be unconditionally demanded.

With these conclusions the most recent results of E. Salkowski (who has not met with our researches), are in complete accord (*Virchow's Archiv*, vol. 120, p. 325). Also the *Versamm. Bayer. Chemiker in Erlangen*, 1890, takes a very similar view.

SECTION XII.

VEGETABLE ARTICLES OF CONSUMPTION FREE FROM ALCOHOL.

1. Tea.[1]

§ 355. *Tea.*—The plant producing tea, *Thea chinensis*, is an evergreen shrub closely allied with the camellia of our conservatories, which is grown not only in China and Japan but in some other subtropical regions.[2] Its young leaves yield the fine teas, whilst the older leaves produce inferior sorts. Tea reaches us principally in two forms:—

Green Tea.—Immediately after gathering the leaves are heated for a few minutes in iron pans, then kneaded, rolled up, and dried in the sun.[3]

Black Tea.—The leaves are first allowed to ferment in heaps, when they assume a dark colour, and are then dried like green tea. Tea for exportation is often scented by interstratifying it with odoriferous flavours, which are sought out afterwards. Green tea for the European consumer is generally or universally[4] coloured by dusting it over with Prussian blue, smalt, indigo, turmeric, clay, or gypsum, in a manner which is certainly harmless. Along with these inoffensive substances, the detection of which would lead us too far, lead chromate is said to be used. (Compare here, as well as upon colouring and the lead lining of the tea-chests, Section XVIII.)

[1] Of the composition of these substances, Table X. gives a general account, which is noticed in the text only in so far as it leads to direct conclusions. As our knowledge of their physiologically active constituents is in many cases still very fragmentary, and a decision on the value of the different sorts can be given with more certainty by the taste and the scent of the expert than by chemical analysis, I have communicated the chemical examination only in so far as it is practically required for the recognition of sophistications.

[2] North India, Queensland, Natal, and in Ceylon, which is distinctly tropical.—*Editor.*

[3] In very moist regions artificial heat is needed for drying.—*Editor.*

[4] This relates to China and Japan.—*Editor.*

In books we find much said concerning all possible falsifications of tea by the leaves of other plants. Dozens of plants (cherry, sloe, willow, willow-herb, ash, strawberry, &c.) are said to have been used as substitutes. Hilger mentions, on the contrary, that he has only once detected an admixture of willow-leaves. In a series of examinations of tea of the cheapest sorts and tea-dust, I was not able to detect any sophistication with strange leaves.

Falsifications of tea are carried on in Russia on the most extended scale by admixture with epilobium leaves or exhausted tea-leaves. See Tichmorow's careful studies (*Vierteljahrschrift in den Fortschritte u. d. g. der Chemie der Nahrungs und Genussmittel*, 1890, p. 444. Good figures, macroscopic and microscopic, may be found in Mace, *Substances Alimentaires*, Paris, 1891. In the Caucasus, *Vaccinium arctosdaphyllos L.* is used for the falsification of tea, and it has already reached England under the name Batum tea.

§ 356.—For botanical investigation tea-leaves are softened in hot water and spread out upon plates of glass; or they may easily be preserved entire by laying them in glycerine-gelatine or in Canada balsam after previous drying between blotting-paper. Fig. 111 shows the characteristic representation and the course of the nerves of the tea-leaf; particular weight must be laid upon the arched connection of the lateral nerves.

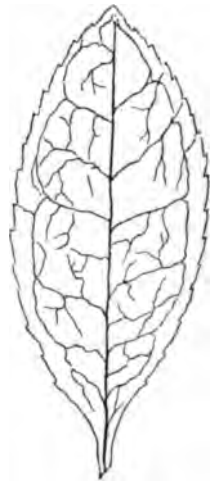

Fig. 111.—Tea-leaf. Natural size.

If the exterior of the leaf gives rise to suspicion, portions, especially from the vicinity of the nerves, are examined under the microscope with a magnifying power of 300 diameter. In a genuine tea-leaf, not too young, we shall rarely fail to find the highly characteristic stone-cells[1] very large, knotty, ramified growths, the length of which almost equals the entire thickness of the leaf (Fig. 113, *id*). Less characteristic are the calcium oxalate glands, which otherwise also are found frequently in leaves (Fig. 113 *K*). In addition there are also on young leaves more or fewer long hairs, often bent at the base in a right angle (Fig. 112 *h*);

[1] The finest teas, consisting of the youngest leaves, often do not display the stone-cells, which should be sought under the main rib of the leaf.

sometimes the young leaves appear quite sappy, whilst the old leaves are often nearly bald. The openings of the fissures (Fig. 112 *sp*) are large, broad, without accompanying cells, not particularly characteristic. The epidermis of the upper and under side of the leaf is not

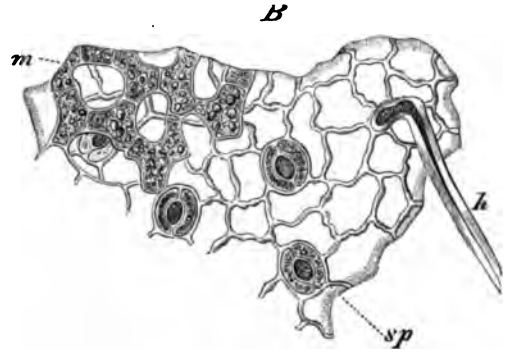

FIG. 112.—Epidermis of the Tea-leaf. After Möller. Magnified 160 diameters.

striated. Dilute potassa-lye, or a saturated solution of chloral hydrate, facilitates the examination by rendering the preparation more luminous.

A doubtful tea-leaf can generally be distinguished from the above-mentioned substitutes by means of these characteristics. But leaves of

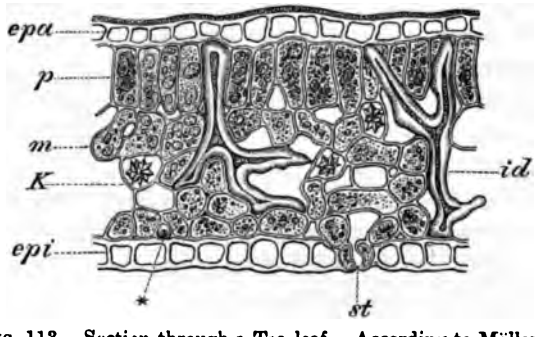

FIG. 113.—Section through a Tea-leaf. According to Möller. Magnified 160 diameters.

other Camelliaceæ (which, unlike the leaves above-mentioned, possess also stone-cells) may be used for the falsification of tea (Riche and Collin, *Chem. Zeit. Rep.*, 1890, p. 42).

Of much more commercial importance than the addition of strange leaves is the mixture of good tea with leaves which

have been already used. This is said to be carried out on the very largest scale. The demonstration of this fraud is difficult even for specialist experts, and this on the following grounds:—

1. We may attempt the determination of thein (caffein), but even in good teas its proportion fluctuates from 1 to 3 per cent.,[1] most commonly from 1·8 to 2·3 per cent.

According to Hilger and Vité, caffein is best determined in tea in the following manner:—

5 *grm.* of tea in powder fine enough to pass a hair sieve with meshes 4 *cmm.* are three times extracted for an hour, using each time 300 *cc.* of water (conveniently done in an egg-shaped tea-filter). The united extracts—neither strained nor filtered—are concentrated down to one-fourth, and then whilst hot mixed with freshly precipitated lead hydroxide, with an addition of coarse-grained sand, previously washed. The mixture is evaporated to dryness on the water-bath, and the whole is extracted for three hours with chloroform in Soxhlet's apparatus. The residue left on distillation is dissolved in hot water, the filtrate is evaporated down in a crystallising capsule or small flask on the water-bath, and the residue is dried at a temperature not exceeding 100° (preferably in a steam-drying closet) and weighed.

2. The percentage of tannin which is decreased by extraction can be restored by the addition of catechu, which at the same time improves the colour. Thus the value of a determination of the extract is rendered questionable.

According to Tichomizow the tannin in the extracted leaves is diffused in the entire leaf, whilst that in the leaves which have not been extracted is confined to certain tissues. The following characteristic is said to be the most important: if dry tea-leaves are laid from one to four days in a solution of copper acetate saturated in the cold, then well washed, cut up into pieces, and dyed with iron acetate; in tea which has been extracted, the idioblasts take a blue-black colour, whilst in unchanged tea they remain colourless. This circumstance had not been regularly confirmed by us.

A determination of the ash furnishes a more important

[1] Evidently certain volatile, odoriferous, and sapid substances (tea-oil) determine the value of tea to a greater extent than does the caffeine. Tea-oil is present to the extent of 0·6 to 0·8 per cent., being more abundant in green than in black tea. Paul and Cownley in England were unable to find any connection between the price of tea and its percentage of caffein.

indication. It must not fall below 3 per cent. nor exceed 7 per cent. Of the ash only from 2·5 to 4 per cent. should be soluble in water, and not more than 1 per cent. must be insoluble in acid. In deciding on a tea, the task of the hygienist is to ascertain if the sort in question is genuine and has not been previously used. Its value as a matter of enjoyment can be better determined by the taste of the connoisseur than by any examination. The substitutes hitherto in use must be pronounced harmless but worthless. Of course there is the possibility of the ignorant addition of unwholesome leaves. Hence every strange leaf found which does not admit of exact determination is to be condemned as possibly hurtful. See § 364.

2. Coffee and Coffee Adulterants.

§ 357. The name coffee belongs only to the seed of the coffee-tree (*Coffea arabica*); the pulp enclosing these seeds is also met with in commerce as "Sakka coffee."[1]

In the cultivation of the coffee-tree in the tropical regions almost of the entire earth numerous qualities of the coffee-bean are obtained differing in form, size, and colour. Sometimes the colour is "improved" by the addition of Prussian-blue, indigo, ultramarine, charcoal, chrome-yellow, ochre, turmeric, china-clay, &c. Coloured unroasted coffee gives off a little colouring-matter to distilled water, but it must be noted that every raw coffee colours calciferous (hard) water green, owing to the presence of viridic acid (caffeo-tannic acid). Coffee is occasionally found falsified with abundance of the shells of the fruits (coffee-flights), small stones, stunted berries, in other words, with coffee-waste.

Spoiled or "haverised" coffee, that is, a product spoiled by the introduction of sea-water, is artificially got up for sale. The common salt must not exceed 0·6 and not fall below 0·15 per cent.

§ 358. Roasted unground coffee is an important article of commerce. On careful boiling scarcely any caffein is lost, but

[1] The Liberian coffee, which has been experimentally cultivated in Trinidad, does not seem chemically identical with that produced by *C. arabica*.—*Editor*.

there is formed "caffeon," an oily substance of an aromatic odour, which takes part in the effects of coffee. The sugar is converted into caramel and other decomposition products.

An increase of bulk takes place in consequence of the tumescence of the beans; the proportion of water is reduced from 12 to 13 per cent. to from 1 to 3, so that the specific gravity of the coffee-beans sinks from 1·041 or 1·368 to 0·5 or 0·65 (Padé). In many cases some sugar, or more frequently crude syrup, is added during burning so as to glaze the beans. The alleged object of the glazing is to prevent the escape of the aromatic substances; it really causes the retention of water in the coffee to the extent of 10 per cent., consequently a gain of about 8 per cent. At the same time the cheap syrup added increases the weight by from 5 to 25 per cent. (König), and coffee thus rich in caramel seems to the public very strong and rich.

According to Stutzer, burnt coffee is often coloured with *caput mortuum*, and made shining with vaseline.

The caffein is determined as follows (method of Hilger and Kornauth); it must not fall below 1·9 per cent., calculated on the dry substance.

5 *grm.* coffee, very finely pulverised, are perfectly extracted with hot water; the extract is precipitated with neutral lead acetate; the filtrate is then entirely freed from lead by passing through it a current of sulphuretted hydrogen, evaporated to dryness with magnesia and sand in a Hofmeister capsule, and the dry residue, finely powdered, is completely extracted with chloroform. The evaporated residue of the chloroform extract is well boiled with water, filtered, and the filtrate concentrated in vacuo to a small volume; the rest of the moisture is then removed in the water-drying niche. The remaining caffein should then be tested microscopically for its purity.

Latterly on the Rhine and in Hungary, among other places, an "artificial coffee" has been introduced into commerce, made up in the form of roasted coffee-beans, from a paste in which there occur acorns, corn, lupins, shells of black pepper, and sometimes even genuine caffein, &c. This fraudulent coffee generally sinks rapidly in the water, whilst genuine roasted coffee floats even upon ether.[1]

The retention of the shape and colour of the coffee-bean shows the object of the mixture to be fraud. The composition of the mixture,

[1] To evade this test falsifiers sometimes shake up ground coffee with a little oil, which prevents it from sinking. This ruse may be defeated by extraction with ether, which dissolves out the oil.—*Editor.*

not easily controlled, renders a right decision difficult from a hygienic point of view. That lupins, which in a recent state have occasioned fearful havoc among flocks of sheep in consequence of the presence of poisons which are imperfectly known, are harmless when roasted, is not yet proven.

Roasted ground coffee has to be tested microscopically for its purity. To this end the powder is thoroughly boiled out with water, and the finest particles are placed at once under the microscope, whilst from the coarser fragments the thinnest possible sections are prepared. Potassa-lye may be added to render them more transparent. The inexperienced observer should prepare himself check-specimens from roasted and unroasted coffee-beans.

Essentially we find in ground coffee merely the knotted, thickened, polygonal, thick-sided endosperm cells (Fig. 114), the contents of which (fat, sugar, and starch) are distorted on roasting. The upper layer of cells of the endosperm has an approximately cubic form. The small embryo has no characteristic tissue. But the thin seed film which is mostly rubbed off the beans, and is only preserved in the groove, has large, rather characteristic, chiefly obliquely porous stone cells, which in ground coffee should appear but sparingly along with the endosperm cells (Fig. 115 *st*).

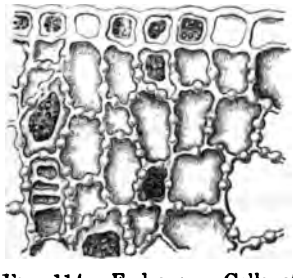

FIG. 114.—Endosperm Cells of the Coffee-bean. After Möller. Magnified to 160 diameters.

§ 359. The falsification of roasted ground coffee is on a very large scale. Most of the adulterants are also sold distinct from coffee, and in all possible combinations and by all possible and fantastic names, as substitutes for coffee, with the alleged intention of substituting for expensive coffee a cheaper and "at the same time nutritious" beverage. Hence we must first examine them alone. The most important adulterants are prepared from chicory roots (beet-roots very often pass by this name).

Figs (especially old inferior fruits); cereals, especially

barley and malt; leguminous seeds, *i.e.* lupins, canevallia, species of astragalus; cassia seeds have some time ago been introduced into the market as negro coffee, and by other names.

All these substances when roasted (and in part mixed with syrup) form brown powders or compact masses, with a variable proportion of moisture. The resemblance of these substances to coffee consists chiefly in the brown colour common

FIG. 115.—Seminal Membrane of the Coffee-bean. After Möller. Magnified 160 diameters.

to all, and in the bitter aromatic taste. The caramel generated during roasting is the chief cause of both these properties. Caffein is entirely wanting in the above-named preparation. Hager's assertion that lupins contain alkaloids similar to caffein in their action is not yet demonstrated. Sakka coffee (§ 357) contains, on the other hand, some caffeine; and kola-nuts, which, it is said, are used for the sophistication of coffee, contain abundance of caffein. Along

with the above-named adulterants there are used, according to authors, at least a dozen other substances.

All the substitutes for coffee colour cold water, in consequence of their large proportion of caramel. All yield to boiling water an abundance of extractive matters, especially sugar, and the brown, bitter products of its caramelisation.

The determination of the extractive substances, according to Trillich, is effected as follows: 10 *grm.* of the adulterant are placed in a beaker with a glass stirring-rod, and covered with 250 *cc.* water; the total weight is accurately determined to 0·1 *grm.*; it is then heated, replacing the water lost by evaporation, and boiled for fifteen minutes from the first bubbling. Particular care must be taken that the liquid does not boil over at the beginning of ebullition; afterwards it boils quietly.

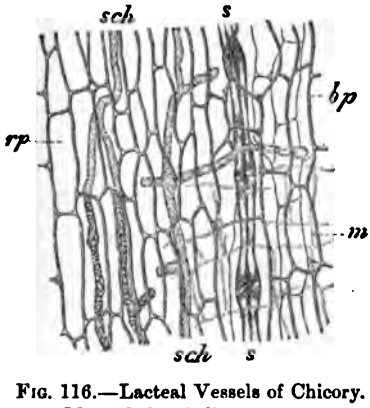

FIG. 116.—Lacteal Vessels of Chicory. Magnified 160 diameters.

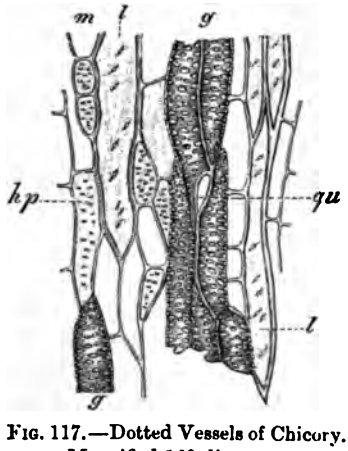

FIG. 117.—Dotted Vessels of Chicory. Magnified 160 diameters.

After Möller.

When cold it is made up to the original weight, mixed, filtered, and the specific gravity of the filtrate determined at 15° by means of the Westphal balance or the pycnometer. In Schultze's table of extracts (Table XIII.) we read off the contents of the solution in percentages by weight = x, and then calculate a, the proportion of extract of the adulterant, the moisture of which, c, is determined separately according to the formula: $a = x \frac{250 + c}{100 - x}$. In this manner Trillich found as a mean for chicory, 70·7 per cent.; for fig coffee, 73·5; for barley coffee, 65 per cent. of extract; on the contrary, for Sakka coffee, only 20, and for genuine coffee about 25 per cent.

In chicory we easily find the vessels (Fig. 117 *g*) densely beset with

aureolated dots extended in breadth; the ramified pipe-shaped lacteal vessels (Fig. 116 *sch*) are also generally found without difficulty; the various kinds of beets also display dotted vessels, and in fig coffee we find lacteal vessels and isodiametric stone-cells. The tissues of the grains of corn, especially the cells of the gluma of barley, rich in silica, and with a wavy outline, are easily distinguished; leguminous seeds are characterised by the pallisade cells of their seed-husk.

The following can no longer be regarded as substitutes (since their extracts are devoid of every similarity with coffee), but purely as adulterants:—date-kernels, wood, turf, spent tanners' bark, &c., which an experienced microscopist may generally detect without special difficulty.[1]

§ 360. From what has been said, the fact of the addition of a substitute to ground coffee is in general not very difficult to establish. The preliminary trial, the brown coloration of cold water on scattering upon its surface ground coffee, certainly gives an affirmative result also with "glazed" coffee (see above), and it may yield as high a percentage of extract as the substitutes.[2] A sophistication with strange powders can scarcely be overlooked on a microscopic examination of comparative preparations. What substitutes have been added can frequently be decided with certainty only by the aid of the text-books of the microscopy of food, and only by the experienced observer.

Injuries to health have never occurred from the rational use either of genuine coffee or of its substitutes. A decision on the value of various sorts of coffee cannot be given by the hygienist, since the laboratory examination is not sufficiently decisive. That sea-soaked coffee, coffee with an amount of water artificially increased, products containing stones, in-

[1] It is singular that a British patent should have been granted for the use of date-kernels as a substitute for coffee. The distinction which the Germans make between substitutes ("*surrogate*") and adulterants (*Fälschungsmittel*) is to be regretted.—*Editor.*

[2] In doubtful cases the ethereal extract is also determined: coffee yields, if exhausted in Soxhlet's apparatus, about 15 to 16 per cent., whilst the substitutes yield only from 1 to 3 per cent. Genuine roasted coffee floats on water, which the substitutes do only if artificially greased (Kornauth). The ash of pure coffee does not exceed 4 per cent.; that of roasted chicory is 4, and that of roasted figs 5 per cent.

ferior or dyed samples, &c., may under certain circumstances be unappetising, or even injurious, is a matter of course. See Section XVIII.

The substitutes, with insignificant exceptions, are devoid of caffein and caffeone, and can therefore have no exciting action. For those who like their taste they may be harmless means of enjoyment. To speak of a nutritive value is an exaggeration, since the trifling quantities of sugar or other extractive substances contained in a few cups of spurious coffee vanish entirely as compared with the requirements of the organism. Whether any of the substitutes which contain no caffein are more valuable than others is not to be decided from a hygienic point of view. Unappetising, sandy, mouldy preparations are of course to be objected to. The presence of hyphomycetes, if necessary, is to be examined by the plate process.[1]

3. Cocoa and Chocolate.

§ 361. The cocoa-tree (*Theobroma cacao* and its allies) is cultivated extensively, especially in tropical America; it bears in its cucumber-like fruits large seeds, which, after they have in general been "rotted" (*i.e.*, undergone a peculiar fermentation), are sent off and submitted to further treatment. The seeds are gently roasted, peeled, and finely ground; the product pressed in moulds is called cocoa-paste. The latter, according to Zipperer, contains about 50 per cent. of cocoa-fat, 4 to 8 per cent. of water, about 10 per cent. of starch, 7 to 8 per cent. of tannin and sugar, 2·9 to 4·8 per cent. of ash (according to Weigmann as a mean 3·56 per cent.), the rest consists of proteine substances and cellulose. Theobromine is present, according to Zipperer, as 0·5 per cent., but according to Weigmann as much as 1·7 per cent. König takes 1·63 per cent. as the mean. The two chief products of cocoa are made from the cocoa-paste.

1. *Cocoa, Cocoa-powder.*—Almost half the fat is removed

[1] Extracts of coffee occur in commerce to a considerable extent, some of which evidently contain little if any coffee.—*Editor.*

by hot pressure, leaving a product containing about 30 per cent. of fat. On heating the residual mass with potash or soda, and an addition of some magnesia (according to prescription up to 2 per cent. of the paste, but in practice often as much as 5 per cent.), there is obtained the Dutch opened or soluble cocoa. The Swiss chemists object to any addition of soda which exceeds 2 per cent., calculated on the weight of the cocoa-powder free from oil.

2. *Chocolate.*—Chocolate is produced by the addition of cane-sugar (up to from 60 to 65 per cent.) and spices up to 1 per cent. (natural vanilla, artificial vanilla, cinnamon, cloves, &c.) to cocoa-paste not freed from fat.

Chocolate, after the deduction of the sugar, should not contain less than 40 or more than 50 per cent. of fat, not more than 3·56 per cent. (on an average 2·13 per cent. of ash). The Swiss chemists do not sanction more than 2 per cent. of ash. The proportion of water is only about 2 per cent.

Falsifications of cocoa and its preparations have latterly become less common. The most frequent are:—

1. Use of the ground shells of the cocoa-seeds, which are very inferior in value, and which are often soiled with earthy substances, and decidedly increase the ash. The ash of the shells varies from 7 to 13 per cent.

2. Occasionally the most varied brown powders: ground barks, powdered bricks, dust, iron oxides, especially the starch of other plants, are added to the preparations of cocoa. Coloured substances are especially requisite if colourless additions are used in large quantities.

3. Sometimes a portion of the natural cocoa-fat is removed by pressure, and there is substituted for it in chocolate mutton-fat, which is cheaper. Or there is added to the chocolate cocoa-fat or mutton-fat, in order to be able to work in more starch or sugar. The fat of the cocoa-nut or dika-fat (from *Mangofera gabonensis*) serve as additions.

The examination of cocoa preparations will scarcely ever become the duty of the physician or the hygienist. Chemists conduct these investigations essentially according to the general methods given in § 209.

The search for adulterants is partly conducted by the analysis of the ash (see also Spices), partly the ethereal extract after the expulsion of the ether is tested for its melting-point (cocoa-fat melts at 30°, cocoa-nut oil at 26° to 27°, dika-fat at 31°, mutton-fat at from 46° to 50°). A microscopic examination detects the presence of shells and strange starches. Along with other characteristic elements the shells have massive vascular bundles with spiral vessels, which only occur rarely in the pure seeds. Cocoa starch is not very readily coloured blue by iodine; it consists of very small, round granules, provided with a slight depression in the middle. Wheat or potato starch, if added, may be easily detected according to § 345; the grains are much larger. If cocoa or chocolate on boiling with water becomes thick or pasty, this indicates an addition of starch, dextrine, or gum.

Decision.—Hitherto, to my knowledge, no preparation of cocoa has ever had a directly injurious action. The addition of mineral or other worthless powders is frequently unpleasant, and, like the addition of shells, diminishes the nutrient value or the agreeableness of the product. Mutton fat seems to me also unpleasant; its nutritive value differs considerably from that of cocoa-fat on account of its high melting-point.

The efforts of the Association of German Chocolate-makers, which deserve public recognition, and the pressure of competition, have greatly contributed to create a beneficial guarantee for the purity and agreeable quality of cocoa and chocolate. Any addition of starch in the cheaper sorts must, according to an agreement among the members of the association, be distinctly shown on the packages in percentage by weight.

4. Tobacco.

§ 362. The leaves of various species of Nicotiana are slightly dried in the air, laid up in heaps, and submitted to processes of fermentation. The fermented leaves are partly worked up without further preparation to cigars and cut

tobacco (for smoking); partly they are mixed with so-called "sauces" (generally saccharine and scented vegetable extracts), and used for snuff and chewing-tobacco. Cut tobaccos are also often "improved" by saucing; covering-leaves or entire cigars are coloured brown, &c.

It is still scarcely known what ingredient in tobacco determines its value as a luxury; along with nicotine there come into question also nicotianine (tobacco-camphor), resins, ammonia, and substituted ammonias, and especially the strongly scented fermentation oils. The smoker inhales partly the combustion, and partly the distillation products of tobacco-leaves—an extremely complicated mixture, in which nicotine falls into the background. It was not detected at all by Eulenberg and Vohl, but it has been detected with certainty by Heubel. In addition there have been isolated in smoke: nicotianine, pyridine, piccoline, lutidine, collidine, sulphuretted hydrogen, hydrocyanic, acetic, and carbonic acids, and, lastly, carbon monoxide.

From the above it cannot surprise us that a chemical examination scarcely decides anything concerning the value of a tobacco as a means of enjoyment. In addition the taste of individual smokers varies extremely.

The proportion of nicotine fluctuates enormously in the different sorts of tobacco, according to variety, soil, and manner of preparation. Ohio is said to contain 0·68 per cent., and Kentucky 4·5 per cent. of nicotine. The finer qualities are often poor in nicotine.

In the examination for a decision on tobacco the following points must be especially kept in view:—

1. All manner of leaves are said to be added to tobacco (beet, nut, potato, &c.), but the frequence of these falsifications seems to have been greatly exaggerated in the older books. As in tea the addition is to be detected by macroscopic, but especially by microscopic examination. The leaves are previously well boiled in water and rendered transparent with potassa-lye. The examination is carried on according to the instructions in Möller's book, with the aid of comparative preparations of the most important leaves. I did not succeed at Munich in detecting parts of strange plants

in five samples of the cheapest tobacco bought at poor shops; of course the cheaper sorts contain more stalks.

The hygienic decision upon such leaves must generally be to the effect that nothing is known of a harmful action of their smoke. Of course any doubt as to the harmlessness, *e.g.*, of potato leaves, will be expressed in the decision as a suspicion of their hurtfulness. The smoke of any substitute cannot easily be more poisonous than that of tobacco-leaves.

2. The various colourings and other preparatory agents of smoking-tobacco or cigars have scarcely any hygienic importance, and just as little the ordinary preparation of snuff, though the latter is got up to a far greater extent with the most heterogeneous sauces, submitted to a more prolonged fermentation, and mixed with perfumes. On the other hand, all manner of heterogeneous additions are said to be frequently used in snuff: powdered wood, glass powder, even powdered hellebore, the two last of which must be condemned from a hygienic point of view, as they may exert violent irritation in an indescribable manner.

3. An entire series of seven cases of lead poisoning in consequence of snuff being wrapped in lead foil. By reason of its acidity the snuff took up as much as 2½ per cent. of lead.

Concerning tin-poisonings by snuff nothing is known.

5. Spices.

§ 363. The examination of the various spices for their trade value or purity is the task of the food- and of the trade-chemist. The chemical, and especially the microscopic part of the investigation, often necessitate thorough independent study. A knowledge of drugs is also often needed for a certain decision. I must here content myself with some general remarks, and a reference to the special literature of the subject, for here, if anywhere, only the most accurate representation can really assist us. The most important[1] spices now in use are for us:—

[1] Only the kinds met with in commerce in a dried or otherwise preserved state are noticed here, not the green vegetables used for flavouring soups, &c.

1. *Leaves:* Bay (*Laurus nobilis*).
2. *Blossoms*, and parts of blossoms.
   Cloves = blossom buds of the clove-tree (*Caryophyllus aromaticus*).
   Capers = blossom buds of the caper-bush (*Capparis spinosa*).
   Saffron = stigmata of *Crocus sativus*.[2]
3. *Fruits and Seeds:*
   Vanilla = fruit-capsules (so-called pods) of the orchidaceous plant (*Vanilla planifolia*).
   Pepper = fruits of the pepper plant (*Piper nigrum*). The fruits dried when unripe yield black pepper; ripe fruits deprived of their outer coat yield white pepper.
   Chillies = fruits of several kinds of Capsicum, especially *Capsicum annuum* (cayenne pepper), known on the Continent as Paprica.
   Pimento = fruits of the pimento-myrtle. *Pimenta officinalis* = all-spice, English spice, new-spice.
   Nutmeg = seeds of the nutmeg-tree (*Myristica fragrans*). The seed-cover of the same tree is known as Mace.
   Aniseed = fruits of *Pimpinella anisum*.
   Fennel = fruits of *Fœniculum officinale*.
   Cummin = fruits of *Carum carvi*.
   Coriander = fruits of *Coriandrum sativum*.
   The last four plants mentioned belonged to the family of the Umbeliferæ.
   Mustard = fruits of *Sinapis alba* (white mustard) and *Brassica nigra* (black mustard).
4. *Barks:*
   Cinnamon, the rind of *Cinnamomum ceylanicum*, and *Cinnamomum cassia*.

More rarely used with us are: Cinnamon blossoms, the buds of the cinnamon-tree, mother-cloves, the unripe fruits of the clove-tree.

Star-anise, the fruit of *Illicium verum*, also the root-stems

[2] Not used in cookery, &c., in Britain, except in Cornwall.

of certain Zingiberaceæ, known as ginger, galangals, and santonica,[1] also the fruits of similar plants, Cardamons.

Sophistications and impurities of the entire unground spices are in general easy to recognise. Stalks, light grains, and sand are at once noticed on picking over a portion, as also mouldiness, a musty smell, &c. The following points are hygienically important:—

1. *Saffron.*—As genuine saffron costs £12 per kilogramme it is falsified to an enormous extent. Entire saffron on softening in water shows the characteristic structure of the cornet-shaped hyla of the crocus, which in well-preserved specimens adhere to the style by threes. Ground saffron is mostly falsified. (Kayser found among 127 sorts 114 sophisticated!) But even entire saffron very often undergoes the most varied additions. The presence of the yellow, harmless flowers of the marigold (*Calendula*) and safflower (*Carthamus tinctorius*) is readily detected by the microscope; it is best to use specimens which have been well boiled in water. Saffron, if thrown upon water, colours it, whilst marigold, safflower, and various preparations got up with aniline dyes do not colour water at all, or but slightly; genuine saffron may be by degrees entirely decolorised with hot water. If scattered upon concentrated sulphuric acid every genuine fragment of saffron becomes surrounded with a pure blue halo which quickly turns brown. Most of the substitutes give a dirty yellowish brown colour; marigold turns to a greenish blue, Potassa-lye decolorises saffron and safflower but little; marigold takes a characteristic yellowish green.

The ash of saffron varies from pure white to greyish white, that of marigold is intensely green from the presence of manganese; the ash of carthamus is a reddish brown from iron. The ash of saffron contains 13·53 per cent. of phosphoric acid, that of safflower 2, and that of marigold 0·37 per cent. (Kuntze and Hilger).

Of the various vegetable additions which decrease the value of the sample there may be mentioned: tender rootlets, cut crocus petals, the stigmas of maize, the flowers of *Lyperia crocea* (Cape saffron), sandal-

[1] It need scarcely be said that in Britain ginger is one of the commonest spices, far more common, *e.g.*, than is saffron.—*Editor.*

wood, bark of Scotch firs, flour. To improve the colour the most varied pigments have been applied.

Among the latter there have been already recognised: Dinitrokresol potassium, aurantia, Victoria yellow, Martius yellow and gold orange, coralline, picric acid, phenylamidoazobenzol-sulphuric acid (Hilger and Kuntze), several of which are powerful poisons. The first mentioned, formerly met with in commerce as "saffron substitute," has occasioned fatal results in human subjects. See § 495*a*.

The diagnosis of these substances is possible only by means of the literature of tinctorial substances cited in § 495*a*, and is always difficult.

For weighting saffron all possible powders have been used, after the saffron has been rendered adhesive, *e.g.*, with sugar, honey, glycerine. Altogether the falsification of saffron is an inexhaustively rich theme.

2. The alleged substitution of other buds for those of capers—formerly common—*e.g.*, *Caltha palustris*, is now probably rare; it is easily detected by the botanist by means of the structure of the flowers, and hitherto it has not been of hygienic importance.

3. *Vanilla.*—Falsifications of vanilla consist chiefly in the substitution of the inferior wild sorts for the more valuable genuine pods. It is also said that samples occur in trade which have been extracted, are scented with balsam of Peru, and sprinkled over with crystals of benzoic acid. The last process is to imitate the valued appearance of many genuine kinds which have a natural coating of vanilline, which has effloresced or crystallised out.

The well-known fact that occasionally after the use of vanilla (especially vanilla ice-creams) severe poisoning has occurred, which takes the type of European cholera, is still unexplained. It is said to have been directly shown that the use of the vanilla-pod alone, and not a milk-ptomaine, or a metallic poison, can have been the cause of the disease. See Fränkel, *Berliner klin. Wochenschrift*, 1873. There are two possibilities. On the one hand, it is conceivable that vanilla-plants which have grown on certain poisonous trees (*Jatropha*

curcas) yield poisonous pods. To me, the hypothesis seems more plausible that a poison is sometimes afterwards formed in the vanilla-pod, since all the pods, gathered whilst unripe, have to undergo a kind of fermentation. Hitherto there is no means, chemical or microscopical, of distinguishing a poisonous from a harmless pod. In a very remarkable case of poisoning with vanilla ices in America, Vaughan succeeded in proving the presence of tyrotoxicon and the non-poisonous character of the vanilla (*Arch. f. Hygiene*, vii.). I believe that in the great majority of cases similar explanations are correct.

In the "vanillism" of the vanilla workers the action of vanilla upon the nervous system is complicated with a skin disease occasioned by mites.

The substitution of vanilla-sugar (sugar mixed with artificial vanilline) has hitherto never been attended with vanilla poisoning, and is hygienically to be approved of.[1]

4. The various cases of poisoning with nutmegs seem to depend only on the ingestion of irrationally large doses (*e.g.*, severe poisoning from the consumption of 1½ nutmegs).

Concerning a peculiar toxicity of the "wild" nutmegs and mace which occasionally appear on the market nothing has come to my knowledge.

The wild "Bombay mace" is of a deep reddish-brown colour, almost tasteless and inodorous. The colouring-matter extracted with alcohol is precipitated by lead acetate in very distinct flocks of an intense red. With pure mace there is only produced a whitish precipitate. The colouring-matter resembles that of turmeric, but may be distinguished by the reactions with boric acid (*Chemiker Zeitung Rep.*, 1891, p. 55).

5. Sophistications of pepper with spurious grains made up of flour, paste, pepper-dust, &c., with the addition of capsicum, have again repeatedly occurred of late.

6. The aromatic, harmless fruits of the Japanese *Illicium*

[1] In view of the rarity and the doubtful origin of the reputed vanilla poisonings, we may well demand much more conclusive evidence before taking this advice and sacrificing the vanilla plantations of the Seychelles, Mauritius, Trinidad, &c.—*Editor*.

verum, Hooker = *Illicium anisatum*, Auct, has repeatedly given rise to poisoning cases, being confounded with *Illicium religiosum*, which is very similar in structure but poisonous. As a spice it seems needless. Much literature on the subject: *Jahresbericht für Pharmakogn.* 1880, p. 268; 1881–82, p. 895; and 1888, p. 72.

§ 364. The non-specialist, except in signal cases, should beware of passing an opinion on the purity of ground spices. Certainly a microscopic examination with reference to special works will often conduct the experienced observer to his object. But even he will often in practice encounter great difficulties, as the falsifier can constantly use new and more suitable substances, *i.e.*, not yet perfectly examined, brought from all parts of the world. We must also remember that the dealer, even with every precaution, cannot supply absolutely pure wares; occasional strange vegetable cells, grains of starch, fibres, particles of dust, and sand will be found in every spice.

That fraud is here carried on systematically is shown, *e.g.*, by the following facts. In 1886, at Vienna, 68 per cent. of all ground spices were falsified (Nevinny); the purest was cayenne pepper (20·5 per cent. of the samples adulterated). Cinnamon and pepper were very impure (with respectively 79 and 86 per cent. of fraudulent samples); of the samples of cloves 100 per cent. were falsified. The adulterants employed were:—

Cereal flours . .	49 cases.	Bread with other matter	8 cases.
Polenta alone . .	42 „	Sandalwood . . .	3 „
Polenta along with other materials . . .	55 „	Palm kernels . .	7 „
Millet alone . . .	23 „	Leguminous seeds .	10 „
Millet and other substances . . .	27 „	Potato-starch . .	1 „
Pears alone . . .	8 „	Ground rice . . .	1 „
Pears with other matter	14 „	Date kernels . .	1 „
Bread alone . . .	9 „	Mother cloves . .	1 „
		Almond bran . .	2 „
		Clove stalks . . .	2 „

Since the last few years there exist special factories, especially in Austria, which produce under the name of

Matta powders from dried pears, bran, certain sorts of millet, mildewed barley, and other inferior and certainly often unpleasant materials. They are coloured and weighted with mineral powders (heavy-spar, calcium carbonate, lead chromate [!]), and form an especial article of trade. There are sorts of different colours, such as pepper-matta, cassia-matta, pimento-matta, which are sold at from $\frac{1}{7}$ to $\frac{1}{15}$ of the price of the genuine article.

A favourite fraud is to add, intentionally, the dirt, stalks, the light grains, &c., obtained in cleansing the good ware, to the other lots intended for grinding.

An important check on the purity of spices, which is available even for an inexperienced observer, is a determination of the ash according to the rules of art (§ 210). All additions of mineral powders, the use of dirty uncleansed material, and of a great number of substitutes, are detected, or at least shown as probable, by the mere determination of the ash.

The polarising microscope also readily detects a number of frauds, *e.g.*, in case of pepper. See Hebert, *Chem. Zeitung Rep.* 1891, xv. 84.

The ninth Congress of Bavarian Chemists in 1890 adopted the following resolution:—

1. In the microscopic examination of spices the impalpable parts must be separated from the coarser by means of a suitable sieve. As far as possible microscopic sections of the coarser particles should be prepared and examined. At least six separate specimens of the material in question should be taken and examined with the microscope.

The retention of permanent preparations of wares found sophisticated or unmarketable is absolutely necessary for the purpose of their production as *corpus delicti*.

2. In determining the proportion of mineral constituents (ash), an elutriation process is recommended according to the result of the microscopic examination.

3. Slight admixtures of single starch grains of the most different kinds in ground spices do not interfere with the marketable character of the wares concerned. Saffron, with

which are mixed separated elements of the tissues of the style, the leaves, the flower, or other parts, is still to be regarded as marketable and not to be condemned.

An admixture of small quantities of the tissues of clove-stalks in cloves leaves the ware still marketable.

4. In examining ground spices only such samples are to be pronounced pure which are perfectly free from every admixture.

5. The highest limits of the proportion of ash in a ware to be considered marketable are:—

	Mineral Constituents.	
	Ash. Per Cent.	Insoluble in HCl. Per Cent.
Black pepper	6·5	2·0
White pepper	3·5	1·0
Cinnamon	5·0	1·0
Cloves	7·0	1·0
Pimento	6·0	0·5
Mace	2·5	0·5
Nutmeg	5·0	0·5
Saffron	8·0	0·5
Ginger	8·0	3·0
Carraway	8·5	2·0
Fennel	10·0	2·0
Cardamoms	10·0	2·0
Aniseed	10·0	2·0
Marjoram	10·0	2·0
Chillies	5·0	0·5

All these numbers refer to the air-dried ware.

The decision on all these falsifications and negligences from a hygienic point of view is as follows: Although hitherto a danger to health from such manipulations has rarely been detected, the physiological efficacy of the spices—which play an important part in the economy of our nutrition—must be greatly enfeebled or perhaps altered (*e.g.* by the substitution of flour mixed with chillies for pepper). Secondly, the possibility exists at any moment that hurtful substitutes may be selected by an unscrupulous industry, of which potassium dinitrokresol, lead chromate, and mildewed cereal grains can already be cited as instances. It is, lastly, unpleasant to consume dirt of all kinds in place of clean spices. These motives determine us in principle to protest from a hygienic point of view against all falsifications of spices.

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SECTION XIII.

BEER.[1]

§ 365. The production of beer is effected, in its main features, as follows:—

Barley is steeped for some days in water, then spread out on cool floors, and allowed to germinate. The ferment known as diastase is formed, and some maltose and dextrine are produced from the starch. The green malt thus obtained is dried in airy rooms, and is then further more or less dried in kilns and separated from the rootlets and plumules. Darker malts, so-called "colouring malts," are obtained by roasting the kiln-dried malts more strongly.[2] During drying a further portion of the starch is converted into dextrine; roasting products are formed; the diastase is little affected.

Then follows an infusion of the bruised malt in hot water, and the starch is converted by the diastase into maltose. This procedure is conducted in different manners in the different methods of brewing. The large quantity of diastase in malt permits of the addition of unmalted grain, *e.g.*, bruised wheat, rice, &c., to increase the proportion of maltose. The final result is a brown sweetish liquid, the wort, which is then boiled up with hops, "hopped wort," freed from suspended flocks of albumenoids by filtration, cooled as rapidly as possible, and pumped into the cold fermenting cellars (3° to 4°). Here the yeast is added, and a moderately rapid alcoholic fermentation is produced at the expense of the maltose. After the chief fermentation is at an end, the new beer is

[1] The author here refers to so-called "brown beer," formed by bottom fermentation. "White beer" he mentions at the end of the section. The reader, German or English, who wishes to compare continental methods of brewing with those adopted in this country is referred to the English works mentioned in the Bibliography.—*Editor.*

[2] Brown and black malts used for colouring porter and stout are dried respectively at 65° to 76°, and at 163° to 220°.—*Editor.*

carefully drawn off clear from the yeast, which subsides to the bottom, and is filled into store-casks, in which it undergoes a slow second fermentation in the store-cellar at 1°. When this second fermentation is over the casks are bunged up, and the yeast is allowed to deposit.

From the malt the beer derives maltose, dextrine, albumenoids, and salts; from the hops, resins, tannin, and a bitter principle. The fermentation produces besides alcohol and carbonic acid a little glycerine and succinic acid, and the salts of the water used in the process reappear. But the presence of a little lactic and acetic acid may always be detected, evidently in consequence of a schizomycetic fermentation.

In Bavaria, beer (brown beer), in virtue of a law recently formulated (May 18, 1868), may be prepared only from barley-malt, hops, and water, with the aid of yeast. As the malt-duty, a rather high tax charged per hectolitre of malt, is in Bavaria an important part of the public revenue, every use of substitutes for barley-malt—crushed wheat, wheat-malt, rice, starch, sugar, &c.—or of foreign additions in general, is punishable as a fraud on the revenue, whether or not it involves an infraction of the German law on articles of food or against the demands of hygiene. This fiscal regulation will, of course, not engage our attention.[1]

A. Examination of Beer.

§ 366. The most important determinations to be made in beer (expressed as *x grm.* in 100 *grm.* of beer) are:

1. Determination of the specific gravity at 15°.

2. Determination of the proportion of alcohol = *A*.

3. Determination of the extract = *E*. Extract is the sum of the non-volatile constituents. This magnitude is also expressed as *extract residue*, as it represents the residue of the extractive substances of the wort which have not been volatilised as carbonic acid during fermentation.

4. Determination of the concentration of the wort = *e*. As on fermentation about two parts by weight of sugar yield one part of alcohol, by doubling the alcohol found in the beer, and adding it to the extract as found, we may calculate

[1] As long as the malt-tax existed in this country the British law on brewing materials was similar to that of Bavaria.—*Editor.*

approximately how much extract the wort contained before fermentation set in. We find, *e.g.*, in the example carried out in the following pages, 3·43 per cent. of alcohol and 7·64 per cent. of extract: $(3{\cdot}43 \times 2) + 7{\cdot}64 = 14{\cdot}50$. This figure would be accurate enough for a rapid expression, but by means of the formula $\frac{100\,(E + 2{\cdot}0665 \times A)}{100 + 1{\cdot}0665 \times A}$ we may calculate the original extract accurately:

$$\frac{100\,(7{\cdot}64 + 2{\cdot}0665 \times 3{\cdot}43)}{100 + 1{\cdot}0665 \times 3{\cdot}43} = 14{\cdot}20.$$

5. Comparison of the degree of fermentation (V). By this we understand the proportion of the quantity of extract $e - E$ (converted into alcohol and carbonic acid) to the total e contained in the wort.

$$e : e - E = 100 : V.$$

$$V = \frac{100 \,.\, (e - E)}{e} = 100 \,.\, \left(1 - \frac{E}{e}\right)$$

In our example the degree of fermentation $100 \,.\, \left(1 - \frac{7{\cdot}64}{14{\cdot}2}\right)$ $= 46{\cdot}22$, or of 100 parts of extract present in the wort 46·22 parts have disappeared by fermentation.

1. Taking Samples of Beer for Examination.

§ 367. As beer, if not drawn *secundum artem*, quickly passes into a modified and useless condition, the following rules must be observed:—

Beer is drawn into new litre bottles of green glass[1] (wine-bottles, not jugs). The bottles, and also the corks, are laid previously for an hour in boiling water, then carefully drained and allowed to cool, filled with beer at the tap, duly corked and sealed. The beer must be examined at once; on prolonged transmission, especially in hot weather, beer, even taken as above, will be quickly somewhat changed. For despatch in summer the bottles must be packed in ice. Hilger asserts that only beer which is already changing (turbid) becomes

[1] The action of light promotes the decomposition of beer.

perceptibly worse on a journey. Good beer scarcely suffers at all by transmission in bottles in summer to great distances without ice.

For bacteriological examination beer is best taken at the bung-hole by means of a large sterilised pipette, and is then examined exactly like water (§ 200), filled into flasks or bottles, and immediately examined further (§ 374). Large store-vats, in which the bung-hole is not easily accessible, are specially tapped at the side, and the fine stream escaping is received in sterilised vessels.

2. Examination with the Senses.

§ 368. Beer is either quite clear (bright) or it shows a more or less distinct opalescence—dust-like turbidity, faint dimness, strong dimness; if the transparence is further decreased it is said to be muddy.

Causes of turbidity may be:

1. *Yeast or bacteria.* Often both mixed; the most frequent kind of turbidity. Easily recognised by the microscope; by means of counting plates Wahl found in bright beer 5, in "fine" beer 18, in "dusty-turbid" beer 82 yeast microbia per cubic centimetre. Emmerich found in beer moderately turbid with yeast 3900 per cubic centimetre. According to Lindner (*Centralblatt f. Bakteriologie*, viii. 697) turbity is often occasioned by Sarcinae.

2. *Resins.* Yellowish granules and crumbs with intervening drops of oil, which dissolve under the microscope in an excess of alcohol or readily in potassa-lye. Rare.

3. *Albumenoid bodies.* Flocculent turbidities which take a yellow colour with iodine.

4. *Starches and dextrines.* No distinct microscopic image; if precipitated by five volumes of alcohol, collected on a filter, and dissolved in a little water, they give a violet red, or red colour with iodised potassium iodide.

The examination of the taste and smell is important. An acid taste shows the necessity of testing for acetic acid (§ 371); a taste or odour of sulphurous acid, mouldiness, &c., indicate examination in these directions.

3. Specific Gravity.

§ 369. The beer, after it has been brought approximately to the temperature fixed for weighing, is well shaken in a flask half filled, to expel carbonic acid, and filtered through

wadding to remove froth. The specific gravity is taken to the fourth place with the pycnometer (§ 20) or Westphal's balance. Aræometers are not sufficiently accurate.

As pycnometers we use, in preference to the instrument described (§ 20), small bottles with a long narrow neck, holding about 50 *cc.* of beer. The neck has a fine graduation, by means of which the quantity introduced can be read off very accurately, without the necessity of filling the bottle each time up to one fixed mark. Before use the pycnometer must be gauged by ascertaining how much it weighs when empty, and what is its weight when filled up successively to different degree-marks with water at 15°.

We find the pycnometer empty		= 11·4513.			
„	„	full to mark 0 = 60·9759.	Contents alone	=	49·5246.
„	„	„ 20 = 61·1859.	„	„	= 49·7346.
„	„	„ 54 = 61·5463.	„	„	= 50·0950.
„	„	„ 60 = 61·6105.	„	„	= 50·1592.

We can easily draw up a table by interpolation. The difference of weight, *e.g.*, at mark 0 and mark 20 = 0·210. If we divide this number by 20, we find as the first part of the table:

Volume at mark 0 = 49·5246 *cc.*
„ „ 1 = 49·5246 + 0·0105.
„ „ 2 = 49·5246 + 2 × 0·0105, &c.

Between the degrees 20 and 54 the increase per degree is 0·0106 *cc.*; between 54 and 60 = 0·0107 *cc.*

The weight of the empty pycnometer should often be checked, as it gradually decreases by the solution of portions of the glass.

Both when gauging the pycnometer, and when using it for the examination of beer, everything depends on the liquids having the exact temperature of 15°. They are brought as nearly as possible to this temperature. The pycnometer, before reading off, is placed for fifteen minutes in water at 15°, and the result is read off whilst standing in the water, touching merely the neck with the warm fingers. Before weighing, the pycnometer must be carefully dried both externally and internally if any moisture adheres to the neck above the level of the liquid; any change of volume thus occasioned is indifferent, since the volume has been read off, and the weight is not affected.

Example.—The above pycnometer full of beer to the mark 41 weighs: 62·4790, contains therefore 62·4790 – 11·4513 = 51·0277 *grm.* of beer. According to the table it holds up to the mark 49·9572 *cc.* of water; the specific gravity of the beer is therefore 51·0277 : 49·9572 = 1·0214.

4. Alcohol.

§ 370. We weigh in a weighed flask 75 *c.c.* of beer correctly to the second decimal; pour the beer into the distilling-flask (§ 3), rinsing the weighing-flask out with about 10 *c.c.* of water, and distil the alcohol with good condensation into a long-necked pycnometer until the distillate amounts to about two-thirds the volume of the beer. The condensation-tube of the refrigerator is drawn out into a long point leading to a funnel placed in the neck of the pycnometer. The distillation is conducted carefully with a small flame, so as to avoid frothing over; if this danger threatens, a high foam rising up on the surface of the liquid, the flame is withdrawn until the froth has subsided, when the distillation can generally be continued with safety. In the worst case the apparatus must be allowed to cool, the flask opened, and a knife-point full of tannin must be added. In this case the residue cannot be used for the examination of extract.

If the liquid in the pycnometer has risen up into the neck it is placed for a quarter of an hour in water at 15°, the volume is read off, the vessel is dried and weighed as above, and the proportion of alcohol is found from the Baumhauer-Holzner table (Table XIV.).

Example.—Flask with 75 *cc.* beer = 106·75 *grm.*, empty flask = 30·15 *grm.*, therefore 76·60 *grm.* beer have been used. The same pycnometer as above was employed. When filled up to the mark 54 with alcohol distillate it weighed 61·0840. Therefore the distillate alone = 61·0840 – 11·4513 = 49·6327. According to the table of corrections the pycnometer up to the mark 54 contains 50·0950 water, therefore the specific gravity of the alcohol, 49·6327 : 50·0950 = 0·99077. According to Table XIV. this corresponds to alcohol at 5·29 per cent. by weight. Considering that the 49·6327 *grm.* distillate have been obtained from 76·6 *grm.* of beer, the actual percentage of alcohol of the beer $\frac{49{\cdot}6327 \times 5{\cdot}29}{76{\cdot}6} = 3{\cdot}427$ per cent. by weight.

5. Determination of Extract.

75 *cc.* of beer weighed in a flask are carefully evaporated down to two-thirds in a capsule on the water-bath, or on an asbestos plate, rinsed again into the flask with distilled water, and made up to the original weight. If no tannin has been added, the residue obtained on determining the alcohol may be employed. The specific gravity of the beer thus watered or freed from alcohol is again determined, and the proportion of extract in percentages by weight can be read off in Schulze-Ostermann's table (Table XIII.).

In the above example the residue after distillation was poured back into the flask, rinsed, and so much water added that the flask with its contents again weighed exactly 206·75 *grm.* The contents of the flask are poured into a dry beaker, mixed, and the pycnometer used above is filled again after it has been previously rinsed out twice with the de-alcoholised beer. The reading showed, *e.g.*, contents up to mark 32; according to the table, the pycnometer holds up to this degree 49·8618 *grm.* water at 15°. The pycnometer when empty weighs 11·4513, and with the de-alcoholised beer, 62·7958 *grm.* Hence the specific gravity is $\frac{62{\cdot}7958 - 11{\cdot}4513}{49{\cdot}8618} = 1{\cdot}0297$. According to Schultze-Ostermann's table, this corresponds to 7·6382 per cent. of extract by weight.

6. Acid (Total Acid, Carbonic Acid, Acetic Acid).

§ 371. Every beer has naturally an acid reaction in consequence of the free acids and acid salts which it invariably contains. It is hence perverse to object to beer as acid—as it is said to have happened—because it reddens litmus-paper.

According to a general agreement, the total acidity is ascertained by first expelling from 100 *cc.* of shaken beer the free carbonic acid by heating for ten minutes to 40° in an uncovered beaker, then titrating with one-fifth normal baryta-water, continuing to add until a drop of the beer no longer reddens neutral lilac litmus-paper. The determination is always to be effected in duplicate, and a drop of distilled water must be placed as a check upon a slip of litmus-paper in order to compare the colour of moist neutral litmus-paper.

Total acidity is expressed either by the number of cubic

centimetres of normal lye which are consumed by 100 *grm.* beer, or as grammes of lactic acid in 100 *grm.* of beer; 1 *cc.* normal lye saturates 0·09 *grm.* lactic acid.

If, therefore, 100 *cc.* have consumed 10·2 *cc.* of one-fifth normal solution of baryta, the total acidity corresponds (if the beer has the specific gravity 1·015) $\frac{10{\cdot}2 \times 0{\cdot}09}{5 \times 1{\cdot}015} = 0{\cdot}182$ per cent. lactic acid.

It is important to ascertain the presence of other volatile acids beside carbonic acid. Acetic acid especially can sometimes be found in considerable quantities. The quantity of volatile acid is expressed by the number of cubic centimetres of normal soda-lye consumed by the distillate of 100 *grm.* of beer.

We work with the Landmann apparatus (§ 212, Fig. 84). Water in full ebullition is poured into the flask *a*, and 100 *cc.* beer in the flask *b*. The volatile acids driven over along with the watery vapour are collected in *d*. It is useful to pass through the cork of *b* a tall and moderately wide upright tube, open above and below, dipping into the water. It affords safety against the reflux of the contents of the beer-flask if from any cause the water should cease boiling.

For the determination of carbonic acid (rarely performed) we perforate the cork of the bottle with a tube of brass or steel, closed with a cock, and provided with a wide, globular enlargement. The cock is cautiously opened by degrees, and the escaping carbonic acid is received in baryta-water as in § 179 *a*. Afterwards the cock is entirely opened, and the contents of the bottle are heated in the water-bath. It is necessary to have small beer-bottles and large receivers of baryta-water.

7. Glycerine.

§ 372. 50 *cc.* of beer are mixed with about 3 *grm.* of caustic lime, evaporated down to a syrup, then mixed with about 10 *grm.* of coarsely powdered marble or sea-sand, and evaporated to dryness. The entire dry residue is pulverised and placed in a capsule of filter paper, which is introduced into an extracting apparatus and extracted for six to eight hours with not more than 50 *cc.* of strong alcohol. To the extract obtained, which is of a pale colour, there is added at least an equal volume of anhydrous ether; and the solution, after standing for a time, is poured into a weighed flask and filtered through a small filter,

and washed with a little alcohol-ether. After evaporating off the alcohol-ether, the residue is dried in the desiccation closet at 100–105°, loosely covered until the weight becomes constant. In beers which are very rich in extract, the ash from the glycerine is determined and deducted. If sugar is present in the glycerine, it also is to be determined according to Soxhlet and deducted.

8. Maltose, Dextrine, Nitrogen, Ash, Preservative Agents.

Maltose (§ 220), dextrine (same section), nitrogen (§ 212), ash (§ 210). Very slow combustion and the avoidance of bright redness are absolutely necessary. A determination of the ash is required for the detection of an addition of sodium bicarbonate. Sulphurous acid (§ 228), salicylic acid (§ 229).

9. Substitutes for Hops.

§ 373. The substances enumerated in § 380 can be sought for with success only by a critical chemist. A parallel experiment must always be made with pure beer. Dragendorff, in concert with his pupils, has worked out the methods very carefully. For Dragendorff's original memoir see Medicus, *Nahrungsmittel*, p. 112. Compare further Adams, *The Analyst*, 1890, p. 121; and Allen and Chattaway, *The Analyst*, 1890, p. 181.

Two methods only can be here described:—

1. *According to Dragendorff*, a falsification of beer may sometimes be detected as follows: It is evaporated down to the half, mixed with an excess of basic lead acetate, rapidly filtered, and the filtrate mixed with a few drops of a solution of gelatine (1 : 20) and sulphuric acid, exactly enough for the precipitation of the lead. If the filtrate has a bitter taste, substitutes must be further sought for.

2. *Detection of Picric Acid according to Fleck.*—500 *cc.* of beer are evaporated to the consistence of a syrup, the residue extracted with ten times its volume of absolute alcohol, the latter filtered off, and the filter well washed with alcohol. The alcohol thus obtained is evaporated, the residue boiled in water, the water of the filtrate evaporated away, the residue extracted with ether, and the extract evaporated. The

residue re-crystallised from chloroform consists only of picric acid, and may be weighed. If the residue is finally covered with a solution of potassium cyanide and caustic potassa and dried on the water-bath, there appears a blood-red spot of isopurpuric acid. 3 *mgrm.* may be determined in 1 litre of beer.

10. Bacteriological Examination of Beer.

§ 374. This is effected exactly as that of water (sample to be taken according to § 367), using the gelatine-wort described in § 58.

The investigation has rather a zymo-technical than a hygienic meaning. Besides the schizomycetes (which principally form acids, and especially lactic and acetic acids), among which pediococci and sarcinæ play a prominent part (Lindner), there occur here various saccharomycetes and hyphomycetes. See Jörgensen. *Die Mikro-organismen der Gährungsindustrie*, 2nd edition, Berlin, 1890, with bibliographic references in detail. Numerous researches are given in abstract in the *Centralblatt f. Bakteriologie.*

It may here be indicated that the various species and forms of yeast are now used in pure cultures for the production of beer, and that "wild yeasts" are recognised as chief enemies to the production of good beer. See § 92 and § 368.

B. Decision on Beer.

1. Nutritive Value.

§ 375. German and Austrian beer contains on an average, according to König:—

	Specific Gravity.	Water.	Alcohol.	Extract.	Albumen.	Sugar.	Dextrine.	Total Acid as Lactic Acid.	Ash.	Wort, concent.	Degree of Ferment.
Winter beer .	1·0144	91·11	3·36	5·34	0·74	0·95	3·11	0·156	0·204	11·95	55·3
Export beer .	1·0176	89·01	4·40	6·38	0·74	1·20	2·47	0·161	0·247	13·73	53·5

For further figures see Table X.

It would be useless to give the limit values of the hundreds of analyses, as both the minimum and the maximum figures present quite abnormal values. In consequence of the abundant proportion of sugar and dextrine, and the appreciable amount of albumen, beer has decidedly a nutritive value which is not insignificant. Even the alcohol, setting its toxic signification on one side, must be viewed as a nutritive substance.

Hygiene must of course pronounce figures which fall below the mean standard of draught beer as inadmissible, since its interest is that the nutritive value of this important means of popular enjoyment and nutrition (especially for women after a confinement, convalescents, &c.) should not be diminished. Beers containing less than 3 per cent. of alcohol, and 11 per cent. concentration of wort,[1] must be pronounced weak, of inferior value, and not calculated to keep. In Bavaria at least 11·8 were formerly prescribed for draught beer, and for lager beer at least 13·7 per cent. extract of the original wort (concentration of wort). Vogel says, "Though this stipulation has long ago ceased to be legally valid, the conviction has gradually made its way everywhere that these values must be preserved, at least in beers of the Bavarian character." Bock is boiled down to 15 to 16, and Salvator to from 17 to 18·5 per cent. Beers which, instead of being made from malt alone, receive an addition of starch, maltose, potato sugar, &c., in the wort, are relatively poorer in nitrogenous substances, ash, and especially in phosphoric acid. This, indeed, may be pronounced a somewhat trifling disadvantage, since the 7·4 *grm.* of albumen contained in 1 litre of malt beer can be reduced at furthest to one-half, whence the balance of nutrition will not be much affected. According to the agreements of the Bavarian chemists the extract of normal beers usually contains 1 per cent. nitrogen = 6·25 per cent. albumen. König, on the other hand, assumes 12 to 13 per cent.; 0·65 per cent. of nitrogen is, according to the agreements, the very lowest limit.

[1] The Swiss chemists demand 12 per cent.

2. Beer which is too New.

§ 376. If the calculation of the degree of fermentation (§ 366) shows less than 48 per cent., it is to be pronounced insufficiently fermented (too recent). Such beer may have a direct injurious action. Firstly, in consequence of the proportion of hop-resin (or of constituents of the hop which are imperfectly known, and which act directly upon the urinary organs). Spasm of the bladder, irritation of the urethra, &c., are symptoms identical with those produced by decoctions of hops (Mori., *Arch. f. Hygiene*, vii.). Not until the further course of fermentation are these resins satisfactorily precipitated out of the beer.

Hygiene cannot express satisfaction that the Bavarian chemists on July 18, 1891, resolved in future to require only a degree of fermentation of 44 per cent., "as the technical advances in the brewing industry permit such beer to be satisfactorily produced, and as it suits better the present taste of the drinking public."

On the chemistry of hops see Greshoff, *Chemische Studien über Hopfen. Allgem. Brauer und Hopfenzeitung*, 1887, No. 83, where the researches of the author and others are carefully given; also Bungener and Lintner, *Zeit. f. das gesammte Brauwesen*, 1891, p. 358.

In "beers of luxury" (*luxus biere*) the degree of fermentation may descend to 45 per cent.; even at this degree the alcohol and extract are abundant enough to produce a beer which will keep. Of course the ash, glycerine, &c., will be increased in a proportion corresponding to the extract or to the alcohol.

3. Sour, Flat, "Long" Beer, and such as is Rendered Turbid by Yeast.

§ 377. Such beers are no longer enjoyable, and may be condemned on this account. Properties hurtful to health are also possible. It is evidently at times doubtful whether a beer is to be referred to one of these categories, when we must proceed according to the following points of view:—

Sour Beer.—L. Aubry, taking his standing upon abundant experience, proposed the following theses on sour beer at the fifth free convention of Bavarian chemists at Würzburg. See also the transactions of the sixth convention at Munich, in which the same views were maintained by Aubry and H. Vogel.

1. Any beer which is characterised by a strikingly sour and bad taste, having an acidity exceeding 3 *cc.* of normal alkali (= 0·27 *grm.* lactic acid per 100 *grm.* beer), and in the sediment and suspended matter of which acid bacteria can be shown in a quantity large, as compared with the yeast, must be pronounced acid.

2. Every beer the total acidity of which does not exceed the limit fixed in the agreement, but which contains an excess of acetic acid, is to be considered as acid if the quantity of the latter from 100 *cc.* of beer requires for neutralisation more than 1 *cc.* of decinormal soda-lye, *i.e.*, when it contains 0·006 *grm.* acetic acid.

According to the views of Vogel and Aubry it is sometimes chiefly the lactic acid, and sometimes rather the acetic acid which gives beer a sour taste.

Eckenroth found beers from the Palatinate and from Munich which were by no means to be regarded as sour, for which 3·5 *cc.* of decinormal soda-lye were necessary to neutralise the distillate. He proposes not to regard a beer as sour unless more than 5·0 *cc.* are requisite.

For healthy persons sour beers are doubtless often harmless, but for convalescents and for persons with sensitive digestive organs they are always hazardous.

Flat Beer.—If beer has stood for some time, especially at a rather high temperature, it loses its carbonic acid, becomes warm and ill tasting, and is no longer enjoyable. Here belong especially dribblings of casks and leavings of beer, which unconscientious publicans sometimes collect and sell again. Such beer is exceedingly offensive. In general, such beer is also sour and spoiled, and may be unwholesome.

"*Long*" *Beer.*—Beer is rendered "long" by certain schizomycetes (Von Laer, *Wochenschrift f. Brauerei*, 1889, p. 1006).

To my knowledge it has never yet proved injurious to health, but it is not appetising.

§ 378. *Beer rendered Turbid by Yeast.*—At the conventions cited in § 377, the Bavarian representatives of applied chemistry resolved, on the motion of Aubry and H. Vogel, that—

1. Beers which are but slightly fermented must, for consumption, be perfectly free from yeast, *i.e.*, yeast must not be present in them in the form of turbidity.

2. Beers which have been thoroughly fermented, which have at least 48 per cent. of true fermentation, and which are otherwise of a normal character, are admissible for use with a slight opacity; it must, however, not be so strong that a perceptible deposit of yeast appears on standing for twenty-four hours at the temperature of a dwelling-room.

3. Beers which are strongly turbid in consequence of yeast, and which deposit much yeast, are unfit for use.

4. Yeasty beers are to be regarded as spoiled only if along with the yeasts bacteria are abundantly present, if a chemical examination shows scope for continued decomposition (acidification), and if at the same time the taste is bad.

Concerning the hurtfulness of yeasty beers, we knew, until lately, very little of a positive nature. It is certain in country districts that much yeasty beer is still consumed in summer without injury; that in the beers of Ziegenhain and Lichtenhain in Thuringia large quantities of yeast are drunk with pleasure—the beer is so turbid that it looks unpleasant in glasses, and is therefore drunk out of wooden cups. In like manner we drink entire masses of yeast in fermenting must. The French prisoners at Ingolstadt received in 1871 daily each two tablespoonfuls of beer-yeast to prevent scurvy, "with the best success." On the other hand, we cannot doubt that the use of yeasty beers often gives rise to severe intestinal catarrh. See Simanowsky, *Ueber die Gesundheitsschädlichkeit hefetrüber Biere* (*Arch. f. Hygiene*, iv.).

The question has been greatly advanced by Neumayer at the Hygienic Institute at Munich (*Arch. f. Hygiene*, xii.). He has proved by an extensive series of experiments on lower

animals and on men that yeast (twelve different kinds) is perfectly harmless, even in very large doses (8 and even 30 *grm.* daily), without the presence of some fermentable substance. If taken with thoroughly fermented beer it produces for the most part merely slight disturbances, but all kinds of yeast have an injurious action if large doses of yeast and copious supplies of fermentable substances (new beer, saccharine solution, &c.) are taken simultaneously. Neumayer proved that both *in vitro* and in the stomach the process of fermentation at 37° generates abnormal products (fusel oils), and substances of an intensely bitter taste, which may have a poisonous action.

The observations of Simanowsky show that every new, yeasty beer must at least be regarded as hurtful to health. Under all circumstances beers, which are generally drunk clear, are not appetising if turbid, whether the turbidity is due to yeast or other suspended matter.

For clarifying turbid beers the following harmless agents are permissible (see *Verhandl. der Bayer. Chemiker in Nürnberg*, 1885):—

Filtering apparatus, shavings of beech or hazel well boiled out, isinglass, *Raja clavata*, and good gelatine. If the clarifying agents are kept for a long time in solution they often spoil and become unpleasant if not injurious.

4. The Use of Substitutes, Preservative Agents, Effervescing Powders, Sodium Bicarbonate.

§ 379. If we take up fully and entirely the point of view that a beverage consisting purely of barley-malt, water, and hops is to be considered as the ideal of beer, and if we gratefully recognise the beneficial results of the Bavarian malt-tax for the character and the universal reputation of Bavarian beer, the following considerations are drawn up from a general hygienic point of view in agreement with the purpose of the book, according to which not everything prohibited on grounds of national economy or fiscal policy is directly hostile to health.

Substitutes for Barley-malt.—Various cereals (wheat, rice, maize, malted or unmalted, potato-starch, maltose, glucose). On the nutritive value of such beer, see § 375; on the question of the unwholesomeness of glucose and the products of its fermentation, see Wine.

All beers brewed with substitutes for malt are said to have the property of retaining carbonic acid very imperfectly. Whilst malt beers contain abundance of carbonic acid at from 12° to 15° and have a good taste, the substitute beers must be cold as ice if they are not quickly to become flat by the escape of CO_2. This is a great hygienic disadvantage, since beer which is too cold readily produces catarrh of the intestines.

Glycerine.—If we find more than 0·25 per cent. of glycerine in beer, it has very probably been added artificially. The addition of glycerine makes the beer sweeter, seemingly richer and fuller in the mouth. An addition of 1 to 2 *grm.* of glycerine per litre is probably not to be regarded as injurious to health, but to many persons this perfectly extraneous addition will appear repulsive. Further, only weak, poor beer will be provided with this addition, and may probably be regarded at once as badly brewed, ill-fermented, or spoiled.

How much glycerine beer may contain as a minimum cannot yet be said. According to Borgmann and Egger, to 100 alcohol there belong about 5·5 to 3·8 glycerine; latterly, in beers prepared with pure cultures of yeast, the glycerine has been reduced to 2·63 per 100 parts of alcohol.

Decoction of Liquorice (for the chemical detection see Kayser, *Rep. d. Anal. Chem.*, 1884, No. 4, and H. Vogel, *Verhandl. der Bayer. Chem. in Nürnberg*, 1885, p. 89).—From a hygienic point of view this substitute may be judged similar to the addition of glycerine in small quantities, *i.e.*, it is harmless but alien, and scarcely appetising.

Saccharine must be judged hygienically according to § 354. It should be strictly prohibited in brewing, for by its sweetening power it enables beers poor in extract to assume the character of the valuable Bock or Salvator beers, rich in extract (K. B. Lehmann). The excuse that saccharine is used merely for preservation is foolish.

Beer-colour and Colouring-malt.—According as the malt used has been strongly or lightly dried the beer is darker or lighter. To produce dark beers strongly roasted colour-malt is added directly to the malt or to the wort, or there is used an extract of high-coloured malt, "beer colour." Under the name "patent colour malt" there has come into use a malt pale on the surface, but dark brown inwardly. Its use protects against an empyreumatic flavour, but it may easily introduce more or less raw starch into the beer. Instead of these colouring agents there is often used, especially if the beer turns out too pale, "beer colour," *i.e.*, burnt sugar (cane-sugar or starch-sugar). There is no certain chemical test to show whether the one or the other colour has been used. Hygiene has nothing to object to these colouring-matters if they have been properly prepared from appetising materials and are not spoiled. It can ascribe no value to the circumstance that an extract of coloured malt contains a little more nutritious matter than the quantity of beer colour which gives the same shade. But very dark beers must be viewed with some suspicion, since the colour (especially formerly) might often simulate a strongly concentrated wort; and, secondly, according to experience, it is sometimes added to conceal turbidities of different kinds. The position of chemists and zymotechnicists on the colour question is still not fully explained, but it is discussed in the Transaction of the fourth free Association of Bavarian Chemists at Nürenberg.

Guyot alleges that he has found methyl-orange in beer at Paris.

§ 380. *Substitutes for Hops.*—The hop has three functions in beer. Firstly, it gives a bitter aromatic taste; secondly, its tannin promotes the elimination of various albumenoids, *i.e.*, clarification; and lastly, it has preservative qualities. As hops in many seasons are rather dear, the idea was obvious to substitute for them other bitter, and, to some extent, tanniferous substances, of which we mention:—

Artemisia absynthium (wormwood), *Ledum palustre* (marsh-rosemary), *Menyanthes trifoliata* (bitter clover), *Coronilla scorpioides*, *Buxus semper-*

virens (box-tree), *Cnicus benedictus* (holy thistle), *Erythræa centaurium* (centaury), the roots of species of gentians, the bark of *Quassia amara* and species of willow, the fruits and seeds of *Colchicum autumnale*, *Anamirta cocculus* (*Cocculus indicus*), *Capsicum annuum*, the pith of colocynths, the resin of aloes, and lastly even picric acid.

Of the above-mentioned drugs some are probably harmless (willow-bark, gentian, centaury), some more questionable (Ledum, Artemisia, Buxus), and a number intensely poisonous (Colchicum, *Menispermum cocculus*, containing picrotoxin); substances containing strychnine are said to have been used;[1] picric acid is a formidable poison, 0·4 *grm.* of which produce serious symptoms. In view of the difficulty of distinguishing these bitters chemically, and the dangerous character of a number of them, a general prohibition of them would be very judicious. No exception should be made even for the harmless kinds, as they diminish the enjoyable character of the beer. The hop certainly contains poisons (§ 376), but the experience of centuries has taught us that no danger is to be apprehended if it is used according to the rules of art.

Ferraud and Chevalier (*Journal de Chemie et de Pharmacie*, 1868) allege that at that time the beer at Lyon was invariably mixed with picric acid, in consequence of which they were attacked with illness. Colchicin has often been really or in supposition found in beer, as also buxin. But as in notoriously pure beers substances have been found which act like curare, the utmost caution is requisite in the chemical interpretation of the results obtained; many able chemists express themselves very doubtingly whether such substances have been really found of late in Germany. See, *e.g.*, L. A. Buchner, *Friedreich's Blätter*, 1883, p. 81.

Sodium Bicarbonate.—Its use is probable if the proportion of ash exceeds 0·3 per cent.,[2] or on titration the total acidity is found less 1·5 *cc.* normal alkali per 100 beer. As soon as an addition of sodium bicarbonate is proved the beer is to be judged as if sour, *i.e.*, it is suspected of being unwholesome. The addition often serves directly to promote the decomposition of the beer; compare Milk, § 284.

[1] This *canard* has been refuted as far as the brewers of English bitter ale are concerned.— *Editor.*

[2] Ash of draught beers 0·13 to 0·25 *grm.*, of lager beers 0·25 to 0·30 per cent.; phosphoric acid, 0·06 to 0·1 *grm.* P_2O_5 in 100 *grm.*

Effervescing Powders.—Publicans sometimes seek to give flat beer the semblance of freshness by means of so-called effervescing powders, containing tartaric acid, along with sodium bicarbonate, which develop carbonic acid in the beer. This is detected, like the bicarbonate, by the proportion of ash. The decision is the same as that on flat beer—it is unpleasant, and, if spoiled, may be directly unwholesome.

APPENDIX I.—DRAWING BEER.

§ 381. If much beer is drawn, and a cask is quickly emptied, the most rational procedure is to draw it with a brass or wooden cock. On the lead in the cocks see Section XVIII.

In many cases it is desired always to draw beer which foams briskly, although the cask may only be slowly emptied. To this end air is forced into the cask by a pump, with the advantage that the beer is forced into the taproom by atmospheric pressure in tubes of tin or caoutchouc. Hygiene disapproves of these arrangements, because very frequently—

1. The impure air of the room is forced into the beer, which must be regarded as unpleasant.

2. If an air-receiver is introduced, the air readily comes in contact with rancid oil.

3. The beer stagnates in the narrow pipes, and takes up metal from the lead pipes (which are often strongly plumbiferous), or odorous (mal-odorous) matters from the caoutchouc pipes.

4. The entire beer-engine, unless very frequently cleansed, gets into a condition of loathsome dirtiness.

These evils are in part not easy of removal. It is better, instead of the beer-engines, to screw a cylinder of liquefied carbonic acid upon the casks remaining in the cellar, by which pure carbonic acid gas exerts the pressure, and no impurity finds its way into the beer. Lintner found that the beer drawn with carbonic acid from a 40-litre barrel was unimpeachable after several days (Lintner, *Zeit. f. d. Gesammt. Brauwesen.*, vol. viii., New Series, No. 5). The temperature

of draught beer should lie between 10° and 15°; if warmer its taste is unpleasant, and if colder it is apt to disagree. The ideal of beer-drawing is, however, direct tapping from the cask without pipes, &c., the cask standing in a cool, airy locality, free from smoke. If it is intended to use compressed carbonic acid as above described, care must be taken that the beer comes as little as possible in contact with pipes or tubes.

APPENDIX II.—SMALL BEER.

§ 382. *Small Beer* (convent, schöps,[1] &c.). There are drawn thin beers for workmen and servants, containing only 1 to 2 per cent. extract, about 1 per cent. of alcohol, 0·06 to 0·08 of ash, and which require for neutralising 100 *grm.* 00·3 to 00·5 *cc.* normal alkali. They are obtained by a repeated extraction of the malt which has been once used for ordinary beer, and treating this thin wort as for beer. The keeping properties of this liquid are very low, and it readily becomes yeasty and sour. Schöps is often made by simply watering beer, which on any account (incipient decomposition) is scarcely saleable.

It is examined like beer; the principal point for the hygienist to decide is whether it is sour or not. This point is found according to the rules given for brown beer. See Prior, *Zur Beurtheilung der Nachbiere; Bericht über die Sechste Versammlung der freien Verein. Bayer. Chem. in München.* 1887.

APPENDIX III.—WHITE BEER.

§ 383. By white beer[2] we understand an acidulous beverage, chiefly obtained from barley and wheat malt by rapid top-fermentation, the properties of which differ much at different places. It is mostly sold in bottles. According to

[1] For complete analysis see Table X. *Convent, kofent, schöps*, German names for small beer.

[2] For complete analysis see Table X.

the resolution of the Bavarian chemists at Nürnberg, 1885, when white beer is required in bottles in a briskly effervescent state and clear, an addition of an enlivening material is necessary in the form of cane sugar. Only by this means can a productive secondary fermentation be kept up in the bottles, as the main fermentation almost entirely consumes the fermentable material.

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SECTION XIV.

WINE.[1]

§ 384. The preamble to the German Act concerning the traffic in articles of food, &c., May 14, 1879, declares unconditionally that the name wine can be given only to a beverage prepared by alcoholic fermentation from the juice of grapes without any addition. In reality alien additions are often made to wine or to the must before fermentation (water, sugar, alcohol, colouring and aromatic substances).

Pure grape-juice contains especially: grape-sugar, levulose, sometimes jointly amounting to from 10 to 30 per cent.; malic acid, tartaric acid (or, in its stead, in the Southern wines, its isomer para-tartaric acid), together from 0·4 to 2·0 per cent.; gum, mannite, albumenoid substances, tannin; phosphoric acid and sulphuric acids combined with calcium and potassium; little sodium chloride.

The fermentation is effected by yeasts which adhere to the skins of the grapes, and are introduced into the must on pressing. If it is desired to produce white wine, the must is quickly pressed away from the skin and stalks; for red wine the skins of purple grapes are allowed to ferment along with the must, yielding thus a wine rich in tannin (from the stalks and in seeds) and in colouring-matter, which is extracted from the skins by the alcohol and the acid.

During fermentation there are formed from the sugars ethylic alcohol and small quantities of higher alcohols (see Spirits), carbonic acid (which escapes), a little glycerine and succinic acid. There always appear traces of esters (*e.g.*,

[1] On sweet wines see appendix to Wine.

ethyl-esters of œnanthylic and caprylic acid), which impart to the wine its aroma (bouquet).

The hope of obtaining wines of peculiarly good properties by adding to the freshly pressed grape-juice pure cultures of suitable yeasts in considerable quantity has hitherto been fulfilled only to a very limited extent. See Müller-Thurgau (*Vierteljahrschrift über den Fortschritt der Chemie der Nahrungs- und Genussmittel*, 1890, p. 464). The sugar is generally fermented away except in traces. If the proportion of sugar is in very considerable quantities, the alcohol which is formed checks complete fermentation, and there remains especially levulose, which ferments more slowly (select wines[1]). The tartar is insoluble in the alcoholic liquid; there separates out a mixture of acid potassium tartrate COOH—CHOH—CHOH—COOK, and neutral calcium tartrate $C_4H_4O_6Ca$ on the sides of the cask. The yeast also deposits at the bottom, and the wine after some time may be drawn into new casks.

The composition of light wines varies greatly, according to locality and season (Table X. gives some mean numbers according to König).

For a general survey the following results by Dietzsch may be communicated. In 100 *cc.* there are:—

	Poor Wines.	Superior Sorts.
Water	92–90	89–80
Alcohol	5–7	7–12
Acid (calculated as tartaric acid)	1·2–0·8	0·8–0·4
Extract	1·5–2·0	2·0–3·0
Ash	0·14–0·20	0·16–0·30

The maximum and minimum values found on the analysis of several hundred pure German wines of the growths 1884 to 1887 are collected in the *Zeit. f. Anal. Chemie*, 1888, p. 729. I quote the following numbers:—

[1] Select wines are obtained from the best-selected grapes of the finest clusters, preferably from the best exposures.

District	Season	Number of Samples.		Alcohol.	Extract.	Acid.	Glycerine.	Ash.	P_2O_5.	SO_3.
Rhenish Hessia	1886	38	Max.	12·0	5·44	0·78	1·30	0·35	0·054	...
			Min.	8·0	1·78	0·42	0·57	0·16	0·022	...
Rh. H. white wines	1887	16	Max.	9·93	5·68	0·25	1·03	0·23	0·041	...
			Min.	5·94	1·99	0·75	0·43	0·16	0·023	...
Rh. H. red wines	1887	7	Max.	8·52	2·83	0·63	0·74	0·29	0·040	...
			Min.	6·96	2·24	0·38	0·52	0·21	0·022	...
Rhine Valley	1887	44	Max.	9·94	3·24	1·38	0·90	0·29	0·057	...
			Min.	5·65	2·03	0·56	0·45	0·14	0·026	...
District of Ahr and Mosel	1884–87	13	Max.	10·60	2·90	0·86	...	0·33	0·061	0·087
			Min.	6·52	1·98	0·51	...	0·14	0·025	0·009
Baden	1886–81	24	Max.	9·5	2·70	0·84	0·81	0·36	0·065	...
			Min.	3·3	1·62	0·42	0·41	0·17	0·013	...
Baden	1885	58	Max.	8·9	2·45	0·94	0·78	0·35	0·042	...
			Min.	3·3	1·50	0·40	0·29	0·15	0·012	...
Of all samples, including districts not mentioned here			Max.	12·0	5·68	1·38	1·30	0·49	0·071	0·096
			Min.	3·2	1·48	0·30	0·32	0·12	0·012	0·007

A. Examination of Wine.

§ 385. Since a Commission which came together in 1884 in the Imperial Office of Health has agreed upon unitary methods for the analysis of wines, they must be taken as a basis for all examinations of wine, as by this means alone can comparable results be obtained. In the following passages only the methods of hygienic importance will be verbally quoted; for other matter we refer to the excellent brief commentary on these resolutions which has been published by Max Barth, the Principal of the Rufach experimental station for the cultivation of wine (*Die Weinanalyse*, Hamburg and Leipzig, Voss, 1884), of which I have made frequent use below.

In like manner the short but clear *Anleitung zur Chem. Analyse des Weines* of Borgmann will prove of the best service.

We especially determine

[illegible]

[illegible]	Total free acid.
[illegible]	Sulphuric acid.
[illegible]	Ash.
[illegible]	Potassium.

Qualitatively.

Sugar.	Alien colouring-matters.
Gum.	

Under some circumstances there may be required a quantitative examination for :—

Sugar.	Salicylic acid (qualitative only).
Volatile acid.	Sulphurous acid.
Tartar and free tartaric acid.	Tannin.
Succinic acid, malic acid, citric acid.	Mineral constituents separately.
	Nitrogen.

All quantitative statements in wine are given as grammes in 100 *cc.*

It would be more consistent to state the constituents as percentages by weight; but these may be found by calculation if the specific gravity is known, which lies outside the limits 0·99 to 1·01 only in strongly sacchariferous or imperfectly fermented wines, and is generally very close upon 1.

1. Sampling and Examination with the Senses.

§ 386. The obtaining samples for chemical examination is often preceded by a trial by specially trained, sworn tasters. But in the inspection of cellars the chemist may personally try the wines, and cause the samples to be taken in well-cleansed bottles, if bottled wines are not in question. If possible, two bottles of each suspected sort should be taken, so that the determinations may all be carried out in duplicate, which is especially needful in case of wines. Until analysis the sealed and labelled bottles must be kept in a locked cellar.

Musts or new wines show, "at the time when the vine blossoms" (*i.e.*, when the cellars become warmer), a disengagement of carbonic acid—an after-fermentation, which is the stronger the richer the new wine is in sugar and the poorer in alcohol. Red wines deposit in the casks, as well as in bottles, a coloured sediment at the bottom, which often appears suspicious to the ignorant, and consists, besides tartar, of earthy salts, colouring and tanning principles, &c.

Such suspicious deposits have to be examined chemically and bacteriologically; sometimes, in case of bottles with everted bottoms, it may happen that grains of shot (lead with traces of arsenic) have got wedged between the glass sides[1] during cleansing. Many wines take a darker colour if allowed to stand open to the air. See § 403, footnote. The observer should beware of giving an opinion founded merely on the smell and taste.

2. Specific Gravity.

§ 387. The determination is performed as for beer, with the Westphal balance or the pycnometer at 15°, and must never be omitted.

3. Alcohol.

§ 388. We proceed exactly as for beer, distilling (§ 3) from 100 *cc.* of wine only 60 to 70 *cc.* into a pycnometer holding 100 *cc.* The distillate is filled up to the mark 100; the contents are mixed by means of a rotary movement, placed in water at 15·5°; finally made up exactly to 100, proceeding further as for beer. The proportion of alcohol is found from the specific gravity according to the Table XV. (Hehner's table).

Besides ethylic alcohol, the principles of the bouquet which may be present, volatile acids (salicylic acid if it has been added, and, in case of sour wines, acetic acid) pass into the distillate; but these trifling quantities exert no perceptible influence upon the specific gravity of the distillate, except in the case of wines which are totally spoiled. In this case it must be neutralised before distillation. The residue from the distillate can be used for the determination of sulphuric acid.

4. Extract.

§ 389. For determining the extract, 50 *cc.* of wine are measured out at 15° C., evaporated down on the water-bath in platinum capsules (of 85 *mm.* diameter, 20 *mm.* depth,

[1] Shot should be entirely discarded for cleansing bottles. Small fragments of quartz are preferable.—*Editor.*

and 75 *cc.* contents; weight about 20 *grm.*). The residue is then heated for 2½ hours in the water-drying niche. Of sacchariferous wines, *i.e.*, wines containing more than 0·5 *grm.* sugar in 100 *cc.*, a smaller quantity must be taken after suitable dilution, so that 1·0 or at most 1·5 *grm.* extract may have to be weighed. By extract residue we understand residue — free acid. (In beer extract, residue = extract; see § 366).

The water-drying niche is a drying-box of metal with double sides, the intervals being filled with water.

It is very important that these directions should be accurately followed as regards the size of the capsules, the length of time, &c. They are supplied by all manufacturers of platinum articles at about £1, 10s, according to the price of the metal.

Indirect Method.—The indirect determination of the extract of wine by ascertaining the specific gravity of the de-alcoholised liquid (as for beer, § 370, 5), and reading off the extract in Schulze-Osternann's table (Table XIII.), gives for ordinary wines results which are more or less discordant. Still more inaccurate is the table drawn up by Hager for the same purpose. These tables are founded on pure extracts of malt. Hager, moreover, had dried the extract of malt which he used for this purpose at 110°, and on this account they were suitable only for the determination of extracts in similar sugary liquids, *e.g.*, for sweet wines in which the direct determination gives unequal results according to the quantity of wine used. The extract of ordinary wines, however, consists merely of traces of sugar with glycerine, acids, and mineral constituents, the specific gravity of which differs considerably from that of sugar. Hence in such wines the extract must always be determined by the direct process exactly as directed, whilst in sweet wines the indirect method is preferable (Haas, *Mittheil. der k. k. Chem. Phys. Versuchsstation Klosterneubury*, part 5, 68).

5. Glycerine.

§ 390. 100 *cc.* of wine (for sweet wines see below) are evaporated down to about 10 *cc.* in a capacious but not shallow capsule on the water-bath; a little quartz-sand and milk of lime[1] are added until the reaction is strongly alkaline, and the whole is evaporated almost to dryness. The residue, whilst being constantly triturated, is treated

[1] Barth (*Pharm. Centralhalle*, 1884, p. 482) states the method more precisely; he uses 2 *grm.* quartz-sand, and from 3 to 4 *cc.* of milk of lime, which has been well shaken up, and which has been obtained by making up 151 calcium oxide with water to 500 *cc.*

with 50 *cc.* alcohol at 96 per cent. by volume, boiled on the water-bath whilst stirring, the solution is passed through a filter, and the insoluble matter is exhausted with small quantities of the same alcohol at the same temperature, which generally requires from 50 to 150 *cc.*, so that the total filtrate makes up from 100 to 200 *cc.* The alcoholic extract is evaporated on the water-bath to a syrupy consistence. The evaporation of the main quantity of the alcohol is not excluded. The residue is taken up with 10 *cc.* of absolute alcohol mixed with 15 *cc.* of ether in a vessel which can be stoppered, allowed to stand until it is clear, and the clear liquid is decanted off and filtered if needful[1] into a light weighing-glass capable of being closed with a glass stopper. Here it is cautiously evaporated until the residue no longer flows, and then dried for one hour in the water-drying niche. When cold it is weighed. In case of sweet wines[2] (more than 5 *grm.* of sugar in 100 *cc.* of wine), we add to 50 *cc.* in a spacious flask a little sand, and a sufficiency of slacked lime reduced to powder are heated, and the flask is heated on the water-bath with occasional shaking. When cold 100 *cc* of alcohol at 96 per cent. by volume are added, the precipitate formed is allowed to settle, filtered off from the liquid, and washed with alcohol of the same strength. The alcohol of the filtrate is evaporated away, and the residue is treated as above directed.

Caution is necessary in boiling out the calcareous dry residue with alcohol; the mass covered with alcohol must be well and continuously triturated with the pestle, otherwise it is apt to spirt. A large water-bath and a small flame must also be used lest the alcohol should become ignited.

If a determination of glycerine has to be undertaken (see decision, § 401, 5), in order to detect an addition of glycerine or alcohol to wine, this procedure must be exactly followed, otherwise we obtain quite different results from which false conclusions might be drawn. The determination of glycerine is at once a weak and an important point in the analysis of wine. What we ultimately weigh as glycerine differs very greatly in colour and odour from genuine glycerine; it is very impure glycerine.

In forming a decision all the relations of the constituents of wine, as observed, have to be referred to the glycerine so obtained, and in default of anything better we have to take this so-called glycerine into account. On the one hand it contains nitrogenous substances (possibly also mannite), and on the other hand genuine glycerine is volatilised during evaporation and drying. But if we always work in a perfectly uniform manner we obtain quite uniform results, which alone can be here decisive.

[1] The sediment can be rinsed with a mixture of one part absolute alcohol and 1½ part ether.

[2] For sweet wines the process is especially untrustworthy.

6. Free Acid. (Totality of the Constituents of Wine having an Acid Reaction.)

§ 391. Just as in beer the acidity is always calculated as "free lactic acid," so in wine it is always reckoned as free tartaric acid. In reality it is affected by the presence of acid salts, especially tartar, acid potassium tartrate, and also by phosphates, malic acid, &c.

25 *cc.* of wine are drawn off with a pipette into a beaker, shaken to expel carbonic acid, and titrated with decinormal (or one-fifth normal) soda-lye. Whoever has the necessary experience can, even without an indicator, recognise the final point approximately by the fact that a newly added drop of the lye produces no change of colour at the spot where it falls into the liquid, since the colouring-matter, especially of white wines, acts as a natural indicator. The titration is, however, always repeated a second time, adding 0·5 *cc.* less lye than in the first experiment, titrating drop by drop, and (as in beer) after every agitation placing a drop with the end of the stirring-rod upon very sensitive litmus paper until it is no longer reddened.

If we titrate 25 *cc.* of wine with one-fifth normal lye, a simple multiplication of the cubic centimetres consumed by 0·06 gives the quantity of free tartaric acid sought for. If, *e.g.*, the quantity of wine used was 9·4 *cc.*, then $9{\cdot}4 \times 0{\cdot}06 = 0{\cdot}564$ *grm.* free tartaric acid contained in 100 *cc.* of wine (1 *cc.* of normal lye = 0·075 tartaric acid; therefore $4 \times \frac{0{\cdot}075}{5} \times 9{\cdot}4 = 0{\cdot}564$).

7. Volatile and Fixed Acids.

§ 392. The volatile acids are determined as in beer, and calculated as acetic acid. We pour (Fig. 84, § 212) 50 *cc.* of wine into the flask *b*, and about 250 *cc.* of water into *a*, and distil until there are about 200 *cc.* in the receiver, the wine being concentrated only to about 15 *cc.*, and must by no means be burned. The titration must be effected with one-fifth normal soda-lye, if, *e.g.*, 3·5 *cc.* have been used. $\frac{3{\cdot}5 \times 0{\cdot}06}{5} = 0{\cdot}042$ *grm.* = 0·084 per cent. acetic acid is present. The determination is generally effected only in such wines as attract attention by a decided acidity.

If it is desired to ascertain the non-volatile acids (expressed as tartaric

acid), the number of cubic centimetres of one-fifth normal lye found for volatile acids are subtracted from the number found by the direct titration of an equal quantity of wine, and the difference is multiplied by $\frac{0{\cdot}075}{5}$, *i.e.*, 0·015.

Example.—50 *cc.* of wine on direct titration consume $\frac{3{\cdot}5}{15{\cdot}3} \times 0{\cdot}015 = 0{\cdot}230$; therefore the proportion of fixed acid calculated as tartaric acid = 0·460 per cent.

8. The Several Organic Acids and the Tartar.

§ 393. The examination of wine for free tartaric, the quantitative determination of free tartaric acid if present, and of the tartar, as well as the determination of citric and succinic acid, are of too little hygienic importance to be here described.

9. Tannin.

§ 394. All determinations of tannin determine also the colouring-matter of wine; such analyses are performed on red wines only.

For an accurate determination the detailed process of Löwenthal-Neubauer-Schrœder must be recommended, in which the wine is mixed with solution of indigo, and titrated with potassium permanganate in presence of sulphuric acid until the blue colour has disappeared. (*Bericht über die Verhandlung der Kommission zur Festellung einer einheitlichen Methode der Gerbstoffbestimmung, geführt am* 10. *November* 1883, *zu Berlin.* Cassel: Fischer, 1885. See Borgmann, *Analyse des Weins*, p. 99.)

For approximate determinations Barth, in connection with the recommendation of the Commission, and improving upon it, proposes the following method :—

He mixes 12 *cc.* of wine with 30 *cc.* alcohol, shakes it up, allows it to deposit, filters off 35 *cc.* (corresponding to 10 *cc.* of the original wine), evaporates it down to about 6 *cc.*, and makes it up with water to 10 *cc.* If necessary, the free acid is neutralised down to 0·5 *grm.* in 100 *cc.* 1 *cc.* of a 40 per cent. solution of sodium acetate is added, and lastly, avoiding excess, a 10 per cent. solution of ferric chloride. There is now formed a precipitate, from the volume of which, after standing for twenty-four

hours, the proportion of tannic is found. In order to read off the volume accurately, the determination is effected in test-glasses 18 *mm.* in width in their upper part, but contracted in their lower part to a width of 8 *mm.* and graduated. The quantities of precipitate signify the following percentages of tannin :—

Cubic Centimetres of Precipitate in 24 Hours.	Tannin in the Wine. Per Cent.	Cubic Centimetres of Precipitate in 24 Hours.	Tannin in the Wine. Per Cent.
0·1	0·003	1·0	0·033
0·2	0·007	2·0	0·066
0·3	0·010	3·0	0·10
0·4	0·013	4·0	0·13
0·5	0·017	5·0	0·17
0·6	0·020	6·0	0·20
0·7	0·023	9·0	0·30
0·8	0·027	12·0	0·40
0·9	0·030		

If from any cause the precipitate will not settle, the relative colour and the transparence of the thicker and thinner stratum in the test-glass are as follows :—

Percentage.	Colour.	Transparence of Thick Layer.	Transparence of Thin Layer.
0·05	Black greyish blue.	Opaque.	Slightly translucent.
0·02	Do. do.	Translucent.	Transparent.
0·01	Dark greyish blue.	Distinctly translucent.	Distinctly transparent.
0·005	Light greyish blue.	Do. do.	Do. do.
0·002	Distinct greenish yellow.	Do. do.	Do. do.
0·001	Very faint greenish yellow.	Do. do.	Do. do.

It has been further proposed (Girard) to soften about 5 *grm.* of catgut (violin strings before oiling) in water, to wash repeatedly, twist, dry, and after weighing to allow it to lie for a couple of days in 100 *cc.* of wine. After the membrane (which is thus tanned) has been washed and dried until the weight becomes constant, the tannin is found approximately by the increase of weight.

10. Sugar.

§ 395. Sugar is to be determined after an addition of sodium carbonate by Fehling's method (using separate solutions, according to § 215), and in wines rich in sugar (*i.e.*, containing more than 0·5 *grm.* sugar per 100 *cc.*), with observance of the modifications indicated by Soxhlet and Allihn (see § 219), and to be calculated as grape-sugar. Strongly

coloured wines, if their proportion of sugar is low, are to be decolorised with purified animal charcoal; but if the sugar exceeds 0·5 per cent., with basic lead acetate, and then to receive an addition of sodium carbonate (see § 396).

If polarising points to the presence of cane-sugar (for details see section on polarisation), the sugar must be again determined after the inversion of the solution. (Heating with hydrochloric acid in the manner indicated. Cane-sugar is calculated from the difference.)

The decolorising agents remove colouring-matter and tannin, which are also reductive. As animal charcoal retains sugar from strong sugary solutions, its use is inadmissible for wines containing much sugar.

For a general indication of the percentage of reductive sugars Barth recommends the following process:—

5 *cc.* of the alkalised wine are placed in a test-tube with 3 *cc.* of Fehling's solution, and heated in a water-bath in full ebullition until the liquid floating above the precipitate is perfectly clear; if it still shows a distinct blue tint 5 *cc.* more of wine are added. If after subsidence decoloration appears, the proportion of sugar lies between 0·2 and 0·1 per cent. If a blue colour still remains the wine contains less than 0·1 per cent. of sugar. If the proportion of sugar is more than 0·2 and less than 0·5 per cent., the experiment is repeated with 5 *cc.* of Fehling's solution. But if the percentage of sugar is greater than 0·5, it must be ascertained more exactly according to § 219. Reischauer's star (§ 220) may also be conveniently used for the determination of small quantities of sugar.

11. Polarisation.

§ 396. For examination in the polarising apparatus wine must be decolorised. To this end we proceed as follows:—

1. In white wines 60 *cc.* are mixed in a measuring-cylinder with 3 *cc.* of basic lead acetate, and filtered. To 31·5 *cc.* of the filtrate we add 1·5 *cc.* of a saturated solution of sodium carbonate, filter again, and polarise the filtrate. We thus obtain a dilution of 10 : 11, which must be kept in mind.

2. In red wines 60 *cc.* of wine are mixed with 6 *cc.* of basic lead acetate; to 33 *cc.* of the filtrate there are added 3 *cc.* of the saturated solution of sodium carbonate; the liquid is again filtered and polarised. The dilution here amounts to 5 : 6. The above relations (in white and red wines) are selected, so that the last filtrate suffices to fill the tube 220 *mm.* in length, the capacity of which is about 28 *cc.*

The filtrate from the basic lead acetate precipitate must be colourless; if this is not effected by the quantities of basic lead acetate indicated, which may be the case with the deeply red wines of southern regions, the addition of lead acetate, and accordingly the subsequent addition of solution of sodium carbonate, must be increased in proportion.

It is absolutely necessary to filter off the first lead precipitate before precipitating the excess of lead with sodium carbonate, as otherwise the soda would act also upon the lead-compound of the colouring-matter, so that we should finally obtain dirty yellowish brown or green liquids, which cannot be polarised.

In place of basic lead acetate we may use for decolorisation the smallest possible quantities of purified animal charcoal. In this case an addition of soda is not required for polarisation, and the volume of the wine is not altered.

The examination of polarisation is always undertaken in a tube 220 *mm.* in length.

In pure wines there occur the following substances capable of acting upon the plane of polarisation of light:—

1. Small quantities of dextrose and levulose. Only in select wines and in southern wines there occur considerable quantities of unfermented sugars, among which levulose predominates as being less easily fermented.

2. Tartaric acid (dextro-rotatory), and some constituents not accurately known.

Thoroughly fermented wines, which have been artificially sweetened when in the state of must, behave in the polarising apparatus like ordinary wines, if merely invert-sugar, cane-sugar, or pure crystalline grape-sugar[1] has been used. If the quantity of sugar added is very large, or the entire quantity is not thoroughly fermented, the same conditions occur as in select wines (levo-rotation), but of course there is dextro-rotation if non-inverted cane-sugar or (rare) unfermented grape-sugar is used. But cane-sugar is usually inverted by the ferment; invert-sugar is levo-rotatory.

If impure glucose (starch-sugar, see § 352) has been added, we find, along with dextrose which may have escaped fermentation, more or less of a substance allied to dextrine and strongly dextro-rotatory amyline (Béchamp) or gallisine

[1] As pure grape-sugar is very costly only cane- or invert-sugar is used by the more cautious sophisticators.

(Schmitt, of Wiesbaden). The latter has isolated the substance and studied it closely (*Mittheilungen aus der amtlich. Lebensmitteluntersuchungsanstalt*, Wiesbaden, Director Schmitt, 1883–84). The substance ($C_{12}H_{24}O_{10}$) is, *inter alia*, insoluble in ether, almost insoluble in absolute alcohol, readily soluble in water and dilute alcohol. It reduces Fehling's solution, and, if heated for a long time to 105° in an aqueous solution with oxalic acid, it passes slowly into glucose. It is strongly dextro-rotatory, $a\,i$ = *ca.* 80°. There have been found in eleven commercial sorts of solid starch, sugar from 7 to 21 per cent.

Recently Scheibler and Mittelmeyer have proved that gallisine is identical with the isomaltose; which has been carefully studied by E. Fischer (*Chem. Zeitung*, 1891, p. 79).

The interpretation of the results obtained by a determination of the polarisation, which, according to the Berlin resolutions, are to be expressed in degrees Wild,[1] is to be effected (literally according to Borgmann) by the following consideration and further examination.

I. The Wine shows no Deflection on Polarisation.

This is the behaviour of most pure, perfectly fermented wines.

But the non-polarisation may be effected by the simultaneous presence of the non-fermentable substances of commercial potato-sugar, which are dextro-rotatory, and by levo-rotatory sugar; or by the presence of dextro-rotatory cane-sugar and levo-rotatory invert-sugar, so that in both cases the right- and left-deflection annul each other.

a. We add in a flask to 50 *cc.* of wine 5 *cc.* of dilute hydrochloric acid of specific gravity 1·1, heat for ten minutes in the water-bath, and polarise after decolorising with basic lead acetate.

In presence of unfermented cane-sugar the wine is now levo-rotatory, as, on heating with acid, cane-sugar is converted into levo-rotatory invert-sugar.

b. We mix 50 *cc.* of the de-alcoholised wine, made up with water to its original volume, in a small flask with yeast, well washed, and heat it to 30° in the water-bath until the fermentation is at an end, which is recognised by the cessation of the evolution of carbonic acid. The fermentation varies in its duration according to the quantity of sugar

[1] 1° Wild = 4·6043° Soleil; 1° Soleil = 0·2172° Wild; 1° Wild = 2·8900° Ventzke-Soleil; 1° Ventzke-Soleil = 0·3460° Wild. The degrees of Schmidt and Hänsch are equal to those of Ventzke-Soleil.

contained in the wine, but it is completed in two or three days, even in wines which are rich in sugar. In wines which show no rotation, there either occurs no fermentation, or it ceases after one day. We then decolorise with basic lead acetate and polarise.[1]

If the wine is now dextro-rotatory, the simultaneous presence of levo-rotatory sugar and the non-fermentable substances of commercial potato-sugar is demonstrated.

If no modification of the rotation is observed in *a* and *b*, the absence of unfermented cane-sugar, of the non-fermentable substances of potato-sugar, and of levo-rotatory sugar is certainly established.

II. The Wine is Deflected to the Right on Direct Polarisation.

This dextro-rotation may be due to the presence of unfermented cane-sugar, to the non-fermentable substances of potato-sugar, or to both jointly.

We invert the wine according to I.*a*:

a. The wine after inversion rotates to the left; it contains therefore unfermented cane-sugar.

b. The wine rotates to the right more than + 0·8° Wild. The presence of the non-fermentable substances of commercial potato-sugar is demonstrated.

c. The wine rotates less than + 0·8° Wild and more than + 0·3° Wild. (Pure wines may show a rotation up to + 3° Wild.)

In the last case (*c*) we proceed as follows for the elimination of any dextro-rotatory tartaric acid :—

210 *cc.* of the wine are evaporated to a thin syrup in a porcelain capsule on the water-bath, with the addition of a few drops of a 20 per cent. solution of potassium acetate. To the residue we gradually add with continual stirring 200 *cc.* of alcohol at 90 per cent. by volume. The alcoholic solution, when perfectly clear, is decanted off into a flask or filtered, and the alcohol is distilled or evaporated away down to about 5 *cc.*

The residue is mixed with about 15 *cc.* of water and a little animal-charcoal which has been elutriated in water, filtered into a small graduated cylinder, and washed with water until the filtrate makes up 30 *cc.*

If on polarisation it shows a deflection of more than + 0·5° Wild, the wine contains the non-fermentable substances of commercial potato-sugar (amyline).

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[1] If the wine contains no reductive sugar (or less than 0·3 per cent.), the fermentation experiment may be omitted.

III. The Wine Rotates to the Left on Direct Polarisation.

The wine then contains unfermented levo-rotatory sugar, which may be derived either from sugar originally present in the must, or may have been formed by inversion from cane-sugar added to the must. But it may at the same time contain the non-fermentable principles of potato-sugar and unfermented and not inverted cane-sugar.

We now know that even the dextrinoid substances can be perfectly fermented by the repeated addition of fresh, particularly powerful sorts of yeast (press-yeast). See Borgmann, Fresenius, Immerheiser; but we have not confirmed the observations (List) that such substances occur even in pure wines.

12. Gum.

§ 397. In order to ascertain an addition of gum we mix 4 *cc.* of wine with 10 *cc.* of alcohol at 96 volumes per cent. If gum is present there appears a milky turbidity, which does not become completely clear even after many hours. The precipitate formed adheres in part to the bottom and the side of the glass turned away from the light, and forms little solid lumps. In genuine wine there are formed flocks, which soon deposit, and remain rather loose. For a closer examination it is well to evaporate the wine to the consistence of a syrup, to extract it with alcohol of the above strength, and dissolve the residue in water. The solution is mixed with a little hydrochloric acid (specific gravity, 1·10), heated for two hours under pressure, and the reduction value is then determined with Fehling's solution, and calculated as dextrose. In genuine wines no appreciable reduction is obtained in this manner. Dextrines might be ascertained in the same manner.

13. Ash and its Several Constituents.

§ 398. The extract of 50 *cc.* of wine after weighing is incinerated at a gentle heat exactly according to § 210. If the ash burns white slowly and with difficulty it is abnormally rich in chlorine. Chlorine may be determined in the ash after a cautious previous neutralisation with nitric acid free from chlorine, as in water (§ 175), or gravimetrically, as silver chloride. For a direct titration of sodium chloride in wine, see *Chemiker Zeitung Repert.*, 1891, p. 194.

Sulphuric acid is directly determined in wine as in water (§ 176); a quantitative examination is effected only if a qualitative test has given cause to suspect the presence of abnormal quantitative quantities.

For a preliminary estimate of the quantity of sulphuric acid present Barth proceeds as follows:—

He prepares a solution of barium chloride of known strength by dissolving 14 *grm.* pure, dry, crystalline barium chloride with the addition of 50 *cc.* hydrochloric acid. If we use 10 *cc.* of wine for the test, 1 *cc.* of barium chloride consumed represents 1 *grm.* potassium sulphate per litre of wine. Every 10 *cc.* of wine are therefore mixed with 0·7, 1, 1·5, 2 *cc.*, and, if necessary, more solution of barium chloride. The liquid is boiled, allowed to settle, filtered, and the clear filtrate is tested with solution of barium chloride. The proportion of sulphuric acid is greater than corresponds to the barium chloride which has been added if a turbidity or a precipitate is produced in the filtrate on adding more barium chloride. It is smaller if the filtrate remains clear.

In wines with an ash which has not a distinct alkaline reaction, phosphoric acid is determined by evaporating the wine down with sodium carbonate and potassium nitrate, igniting the residue slightly, and taking it up in dilute nitric acid, applying then the molybdenum method. If the ash is distinctly alkaline its nitric solution may be at once used for determining the phosphoric acid.

If there is any suspicion both the ash (metals) and the wine may be directly tested (arsenic).

Poisonous metals may be introduced into wine by the most diverse causes, *e.g.*, accidental use of arsenic instead of gypsum, cleaning casks with arsenical sulphuric acid, preservation in or treatment with zinciferous or plumbiferous vessels or utensils, cleansing bottles with leaden shot, and formerly often by sweetening wines with sugar of lead. Copper is introduced into wine by sprinkling vineyards with preparations of copper (against the phylloxera), but only in traces which are hygienically indifferent, about from 0·1 to 0·9 *mgrm.* per litre.

Barium may be introduced by the dangerous attempt to remove sulphates from wine (derived from "plastering") by means of barium chloride, if an excess has been used.

14. Preservative Agents (§ 228 and § 229), Nitrogen (§ 212).

15. Colouring-Matters.[1]

§ 399. Red wines are frequently more valuable than white wines from the same situation, whilst pale red wines are less valuable than those of a more intense colour. It has therefore been for a long time often customary to colour such wines. The voluminous literature of the subject contains so much worthless matter that we must feel indebted to Hasterlick (of Hilger's laboratory), who has recently published a many-sided examination of the more recent methods (*Kritische Studien über die bisherigen Methoden zum Nachweis fremder Farbstoffe im Wein. Dissert. Erlangen*, 1889). The following information is mostly taken from his work, in which we also find many literary abstracts:—

1. *Vegetable Colouring-Matters.*[2]—Bilberries, mallows, elderberries, kermes-berries (Phytolacca). The three colouring-matters first mentioned approximate very closely to each other and to the colouring-matter of red wines. The pigment of Phytolacca alone can be accurately detected (even when mixed with red wine) by the reddish violet coloration of the precipitate produced with salts of lead, and which must be filtered off.

The other vegetable colouring-matters give with this reagent greyish blue, blueish green, or green precipitates which can be distinguished from each other at most if no pigment of red wine is present. Caustic lime even permits no certain diagnosis if coloured white wines are mixed with red wines.

Latterly the fruit of the Chilian Tiliaceous plant, *Aristotelia maqui*, has been used for colouring wines, especially in France. The pigment

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[1] White wines, especially the gold-coloured southern wines, are sometimes coloured with burnt sugar (caramel). This harmless colouring may be detected by an addition of fresh white of egg, which has been pressed through a piece of flannel and diluted with an equal volume of alcohol at 15 per cent. Normal white wines give a strong turbidity with this solution, and a much paler filtrate than the original wine, whilst coloured wines do not.

[2] In Germany it has not been customary to search for vegetable colours, on account of the bad methods. I do not enter upon the detection of extracts of dye-woods, the weed-colours (orchil, &c.) betray themselves by the blue colour produced with alkalies.

is nearly allied to that of wine. By the addition of 10 *cc.* of soda-lye at $\frac{1}{2}$ per cent. to 2 *cc.* of wine, we obtain a blueish green or greenish colour, which is permanent if heated, and fades but little, whilst if the maqui colouring-matter is present in quantity there appears a yellowish green colour, which quickly turns to a pure yellow on the application of heat.

2. *Coal-Tar Colouring-Matters.*—Numerous coal-tar colours have been used experimentally both pure and in mixtures for colouring wine, since a beginning was made with magenta in 1878. Chemists were often unable to indicate with exactness the colouring-matter in question, even though they proved the presence of a coal-tar colour beyond all doubt. According to Hasterlick coal-tar colours are certainly present if the following reactions succeed:—

1. On shaking out the wine, slightly supersaturated with alkali, with amylic alcohol the latter is coloured red.

2. On shaking out the wine with ether the latter takes a distinct red colour.

3. Magenta may be certainly detected by shaking out 100 *cc.* wine with 5 *cc.* ammonia and 30 *cc.* of ether, when the ether remains colourless. If it is drawn off with a pipette and allowed to evaporate entirely in a watch-glass along with a thread of wool, the thread becomes rose-coloured even if mere traces of magenta are present.

4. (According to Cazeneuve.) 10 *cc.* of wine are shaken in the cold for a minute with 0·2 *grm.* of mercury oxide, and after settling are filtered through a three or fourfold moist filter. A second portion is treated in the same manner, but it is boiled for a moment after shaking, but before filtration. The filtrate must be clear; a turbid filtrate proves merely that the shaking, ebullition, and settling have not been continued long enough. If the filtrate is not colourless tar colours are present.

Erythrosine, eosine, methylene blue, and some other blue colours escape this method as they are precipitated. A series of other colouring-matters are partially precipitated, *e.g.*, safranine, chrysoidine, chrysoine, methyleosine, yellow II, red NN, red I, ponceau RR.

This method has repeatedly been found not perfect.

Recently Ferreira da Silva (*Chem. Zeit. Rep.*, 1891, 229) alleges that he has not been able to decolorise 10 *cc.* of a pure Portuguese wine with less than 5·0 *grm.* of yellow mercuric oxide.

5. (According to Carpenne, improved by me.) Smear-preparations of press-yeast or other yeast are made upon covering-glasses and allowed to dry. They are then floated for four hours in a watch-glass filled with the wine in question.

E. Heitzmann found in my laboratory, with a little experience a very large number of colouring-matters may be recognised by a distinct red coloration of the cells, whilst ten different genuine red wines gave merely a faint brownish colour. Heitzmann was able to distinguish 3 to 5 *mgrm.* of different colouring-matters in 1 litre of red wine, in five sets of experiments almost without an error. I had given him for examination each time twelve to fifteen samples of red wine, coloured and uncoloured, about which he knew nothing. Bolder additions of from 5 to 10 *mgrm.* per litre yielded very striking results.

No certain result can be obtained by shaking out non-alkalised wine with amylic alcohol, since acid, especially new wine, gives a slight red colour to amylic alcohol. Heitzmann finds 0·5 *mgrm.* magenta, 2·5 *mgrm.* of acid magenta, and from 2 to 3 *mgrm.* of many other tar-colours per litre of wine suffice to render the colour of amylic alcohol much more intense and fiery than it is ever produced by wine alone.

If the amylic alcohol extract or the shaking out of the coloured amylic alcohol with distilled water gives an absorption spectrum with one or two distinct bands between C and E, but especially between D and E, a tar-colour is present (§ 14).

The spectroscopic detection of magenta and acid magenta for such extracts is exceedingly sensitive; the pigments of wine and other vegetable colours are little adapted for spectroscopic detection. It is also impracticable to examine directly with the spectroscope red wines which have been coloured withtar-colours.

B. The most frequent Processes for the Artificial Improvement and Increase of Wine.

§ 400. A. *Procedures in which the volume is not (appreciably) increased.*

1. Addition of alcohol to the wine after fermentation renders it stronger and more permanent (Vinage).

2. Addition of esters (essences, oils of wine, bouquets) renders it more highly flavoured and fragrant.
3. An addition of glycerine makes it sweeter, fuller in the mouth (known as Scheelising); said to be much used in North Germany.
4. An addition of gypsum (plaster) to the pressed grapes. Plastering is used chiefly (or exclusively) with red grapes. The colour of the wine is rendered more fiery; the wines become clear more rapidly, and are earlier fit for carriage, in consequence of the promotion of the fermentation.

The following transposition occurs:—

$CaSO_4$	+	$C_4H_5KO_6$	=	SO_4HK	+	$C_4H_4CaO_6$
Gypsum.		Potassium bitartrate.		Acid potassium sulphate.		Calcium tartrate.

According to Kayser (*Repert. d. Anal. Chemie*, 1882, p. 65), the transposition goes further:—

SO_4HK	+	PO_4H_2K	=	SO_4K_2	+	PO_4H_3
Acid potassium sulphate.		Acid potassium phosphate.		Neutral potassium sulphate.		Phosphoric acid.

This latter reaction is still undecided, and is doubted by many. See Roos and Thomas (*Comptes Rendus*, 1890, vol. cxi., p. 575).

5. An addition of marble dust to the must, in order to take up the free acid (Chaptalising), sometimes along with an addition of sugar (see No. 9 below). If the marble is added cautiously, calcium tartrate separates out instead of tartar. If marble is added more freely, there are readily formed from the free malic acid soluble calcium malates of an unpleasant taste.
6. Addition of red colouring-matters, vegetable or derived from coal-tar (§ 399).
7. Addition of preservative agents: in addition to fumigating the casks with sulphur (hitherto indispensable), there are added sulphites, salicylic acid, &c.

B. *Methods which increase the volume.*

8. The addition of alcohol and water (sometimes with glycerine) to the fermented wine (Mouillage).

9. Gall's process. Must which is too acid is diluted with water until its acidity becomes normal (about $\frac{1}{2}$ per cent.), and then cane- or grape-sugar is added until it contains from 20 to 30 per cent. of sugar (Gallising).
10. Petiot's process. The grapes which have once been pressed are pressed again or several times along with a solution of sugar. The second wine (Piquette) is used either alone or mixed with genuine wine (Petiotising).

    Pezeyre recommends that the grapes which yield 100 litres natural wine should be once more pressed along with 100 litres of warm water + 17 *kilos.* sugar + 300 *grm.* tartaric acid. The wine is said not to be distinguishable by taste from the wine of the first pressing (*premier jus*), and a third pressing still yields a tolerable small wine. Others obtain even larger quantities of wine. Piquettes are in general rich in bouquet-substances, and often contain some unfermented sugar.

11. Yeast wines are obtained by causing sugar-water to ferment with wine-yeast, with an addition of tartaric acid.

Latterly much wine has been obtained by fermenting water and raisins, with the occasional addition of suitable ingredients. A manufacture of wine from water, sugar, tartaric acid, and alcohol, *i.e.*, from purely artificial ingredients, is said to be practised.

C. Decision on Wine.

§ 401. The question is often put to the food-chemist whether a wine just examined is a pure natural wine, and often whether it agrees with the statements on the label as to origin and age, or what additions it may have undergone. The hygienist can and should decide only:

1. Whether a wine in question is free from injurious substances, *i.e.*, whether any other disturbances of health are to be dreaded than those which, according to experience, result from the consumption of similar quantities of pure wine.

2. Whether the wine is fit for a means of enjoyment.

The requirements in this respect must naturally vary according to the purpose which the wine is intended to subserve. In any case no objectionable property must be present, and no disgusting addition must have taken place.[1]

Thus the point of view which hygiene can logically take is, in my opinion, clearly indicated.

In frequent contradiction to existing legislation, to the efforts of so many associations, and to the wishes of numerous consumers and producers of wines, hygiene cannot condemn a wine which meets hygienic demands, even though the analysis or the confession of the producer renders artificial additions indubitable. It must, on the contrary, under some circumstances, warn the public against a pure wine of bad quality as unwholesome. There is sometimes, therefore, for the hygienist a real improvement of wine which he can only praise and recommend.

For instance, R. Kayser (*Vereinbarungen der Bayr. Chem.*, p. 174) obtained experimentally, from a must containing 10 per cent. of sugar and 1·2 per cent. of acid (calculated as tartaric acid), a wine A. When he mixed a portion of the must with the liquid, which he obtained by digesting the lees with warm water, and again pressing them, with the addition of cane sugar, there was obtained, after fermentation, the wine B. No one can doubt that, in spite of the considerable increase of volume, a more wholesome and cheaper product was obtained, whilst A was on the very limit of potability, and in any case would keep very badly.

In 100 *cc.*	Wine A (pure).	Wine B (with Cane-Sugar and Water).
Alcohol	3·85	6·02
Extract	2·32	2·02
Mineral matters	0·26	0·23
Acid (calculated as tartaric acid)	0·945	0·59
Glycerine	0·520	0·86
Sugar	little	little

I do not, therefore, need to examine how various corporations, commissions, and law-courts have pronounced on the concrete question, what kind of improvements of wine are to be allowed or forbidden. These decisions are often discrepant, and are always chiefly dictated by principles of

[1] For a brief conspectus of a hygienic decision upon the several "wine improvements" see end of this section.

national economy and social politics, even though they may be hygienically permitted. In this respect the opinions of the Health Office make a beneficent exception. Just as little have I here to diagnose from each other the concepts of natural wine and artificial wine, of wines properly and improperly gallised, &c., though hygiene would gladly welcome the creation of legal definitions.[1]

It must be remarked that the wine-chemist, even if he has much experience, and is in possession of numerous confirmatory analyses of pure wines from the same district, has often great difficulty in solving the questions laid before him, and indeed sometimes cannot do it with certainty. "Coupage," the artful mixture of wines in order to produce sorts which the public like to buy, has been highly developed, and renders the task of the chemist difficult. Even the detection of additions to wine is not always practicable when the wine-sophisticators go to work cautiously, and use pure ingredients. It is even said to occur not rarely that cautious sophisticators sometimes ascertain, by sending a sample to the establishment for investigation, whether modern science can detect any fault in the artfully concocted preparation—which, they allege, "has been offered them for sale." Such faults may mostly be corrected if the deceivers possess an accurate analysis! For an interesting case of conflicting decisions on one and the same wine see the *Pharmak. Jahresbericht*, 1883-84, p. 1025, where two opinions by Kayser and Nessler, based upon an accordant analysis, are contrasted.

In the sequel rules for a decision on the purity of wine are given only in so far as it seems necessary in the interest of the completeness of the hygienic considerations, and for explaining to the physician the results of the chemist; everything here mentioned is taken from the report of the "Commission."

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[1] So much only may be mentioned. In the "considerations" which the "Commission" appends to its methods it utters annihilating words on the comprehension of the wine question which prevails in our courts. "If there takes place an addition of the above solution of sugar (sweetened extract of lees 2 *kilos.* and water 2 *kilos.* each, to 1 *kilo.* of sugar) to the must in moderate quantity, it can in by far the most numerous cases not be chemically detected in the wine. If it is declared by authority that the sale of such improved drinks is an offence against the law on articles of food, honest persons will avoid improving wine. But they can then in most cases not compete with other producers and dealers. The danger is at hand that by interfering with the rightful improvement of sour musts, the wine-trade may be driven into the hands of dishonest people."

But the answer is often not easy even when the questions of the hygienist are thus more narrowly limited. As the action of a number of the substances which come here into consideration has not been accurately examined, and as many additions, harmless in themselves, may be used in a state of greater or less impurity, a cautious decision is in general advisable.

The German Bill on the sale of wine—which has been much criticised, and has not yet become law—took up entirely a hygienic point of view (*Chem. Zeit.*, 1887, p. 367), and its first section—which alone concerns us—runs, avoiding any definition of wine, as follows:—

"No wine, beverages containing wine or resembling wine, to which, during or after their preparation, there have been added compounds of barium, metallic lead or lead compounds, glycerine, kermes-berries, compounds of magnesium, salicylic acid, impure spirit (containing free amylic alcohol), uncrystallised starch-sugar, tar-colours, or mixtures containing any of these substances, or which contain in 1 litre of liquid more sulphuric acid than occurs in 2 *grm.* neutral potassium sulphate, may be kept commercially for sale, or sold to others for the purposes of food or enjoyment. The same prohibition extends to the same class of beverages to which there have been added, during or after their preparation, soluble salts of aluminium (alum, &c.), or mixtures containing such substances. Effervescing wines underlie this prohibition only when more than 0·01 *grm.* alum is contained in 1 litre."

We have now to consider the hygienic importance of the several constituents analytically ascertained.

1. *Alcohol.*—Too small a proportion of alcohol (below 4 or 5 per cent.), whether natural or caused by dilution, causes the wines to appear of bad keeping properties. A wine with a proportion of alcohol below 4 per cent. does not meet the demands which we are accustomed to make on wine as an article of enjoyment.

Against too high a percentage of alcohol it can at most be objected that such wines are too intoxicating; but the best

wines have exactly this property.[1] But hygiene is perfectly in accord with the proposal that sweetened and watered wines should not contain more than 9 per cent. of alcohol, as its object is to combat strongly alcoholic, cheap beverages.

For the artificial increase of the percentage of alcohol the best refined spirit is generally used,[2] which has no other effect than that produced by the fermentation of grape-juice. The use of badly purified, fuseliferous spirit in the manufacture of wine (not easily detected, even by the experienced chemist) must be judged toxicologically according to Section XV.

2. On the "bouquet" substances (esters of various alcohols, especially the higher) which occur in every wine, but are sometimes added in abnormally high doses by manufacturers of wine, there is a work by Poincaré and Valois (*Pharm. Zeitung*, 1886, No. 11), from which it appears that large doses of these compounds are hurtful, but small proportions, such as might be added to wine, unobjectionable.[3]

3. *Sugar.*—In connection with alcohol the proportion of sugar may be here considered. Wines which have been thoroughly fermented contain usually from 0·01 to 0·1, or at the utmost 0·25 per cent. of sugar. A higher percentage in a German wine, other than one made from selected grapes, signifies either incomplete fermentation or the addition of sugar to the wine after fermentation. In no case does the presence of sugar signify unwholesomeness.

For the preparation of the finer wines the must is at present sweetened chiefly with invert-sugar, which is either purchased ready-made (almost free from acid), or is prepared

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[1] This may be called in question. The "*grand crus*" of Burgundy, Imperial Tokay, &c., are less intoxicating than the low, brandied sherries too commonly sold in England.—*Editor.*

[2] The Paris Académie de Médecin has formally pronounced the addition of alcohol to wine, according to modern custom, unwholesome. The Academy does not protest against the addition of sugar to must if only crystallised sugar is used (*Weinlaube*, 1886, p. 404). A hygienic basis for this view seems to me impossible.

[3] Unfortunately I can give no further information concerning this work, as I have been unable to obtain it either in the original or in a full abstract.

by the wine-grower by inverting the finest cane-sugar with a little sulphuric acid. Against these products, which border very closely upon the constituents of grape-juice, absolutely no objection can be raised on the part of hygiene. As little can be urged against crystallised glucose, or against pure cane-sugar which is first inverted by yeast and then fermented.

The conditions are less clear as regards starch-sugar, *i.e.*, glucose manufactured from starch.

The above-mentioned non-fermentable constituents of starch-sugar, amyline, or gallisine (§ 396), were for a long time considered as very poisonous,[1] especially on account of some experiments by Schmitz and by Nessler.

Schmitz (*Dissertation*, Bonn, 1878) has subcutaneously injected, especially into animals, residues of the fermentation of potato-sugar, and with these preparations he has obtained generally pain, but almost always at the same time lassitude, stupor, trembling, &c. An injection of the extract of gallised wine gave rise, in a young dog, to repeated vomiting. Only one feeding experiment was made with a purified preparation by Neubauer, and it took no effect. Two experiments made on men, on the different action of gallised and non-gallised wines, gave no concordant results. Nessler, in 1880, observed in two experiments on himself and on Barth, on the use of bitter and ill-flavoured residues of fermentation free from alcohol, headache, sweating, and on one occasion vomiting. (For details see Schmitt.)

But recently (1884) Von Mehring (*Deutsche Vierteljahrschrift f. öffentl. Gesundheitspflage*, vol. xiv.), in eleven experiments on animals (including man), and Schmitt (of Wiesbaden), along with his medical colleague, A. Pfeiffer, observed no injury either from impure residues of fermentation and crude potato-sugar, or from carefully purified gallisine and strongly gallised wines. Schmitt even alleges that he has used as the material for his experiments the same potato-sugar which Nessler had employed in his researches. Von Mehring even does not hesitate to pronounce the non-fermentable substances, like dextrine, good nutriments. Recently Scheibler and Mittelmeyer have even

[1] In the latest edition of Elsner's work, 1889, we read that the injurious action of the non-fermentable part of starch-sugar upon the organism of man and other animals, though formerly often denied, is now placed beyond all doubt.

demonstrated that gallisine is identical with E. Fischer's isomaltose (*Chem. Zeitung*, 1891, p. 79).

I must admit that these investigations have led me to the conviction that a variety of conditions must co-operate for the origin of poisonous substances in gallising, if, indeed, they do originate; gallisine is in any case not responsible for the toxic action. But I cannot yet, like Schmitt, undertake the responsibility of pleading for potato-sugar. Hygiene has nothing to object to the use of pure sugar of well-known qualities (grape-sugar, cane-sugar, or invert-sugar), but it has no cause to advocate impure potato-sugar in opposition to these well-known substances, even though it may be cheaper by a few "pfennige,"[1] and yields a mouth-filling preparation. Wine has not to serve as an article of food.

The addition of saccharine is to be judged according to § 354. According to trials made at the experimental station for the growth of wine and fruit at Klosterneuburg, 0·001 per cent. of saccharine perceptibly improved the flavour of wine, 0·002 per cent. distinctly, and and 0·003 per cent. very remarkably. A larger addition than the latter, *i.e.*, 3 *grm.* per hectolitre, is not to be recommended. Such small quantities are also pronounced harmless by the "Austrian Supreme Sanitary Council."

4. *Extract.*—From the proportion of extract no conclusion can be drawn as to unwholesomeness. But for the sake of completeness room may here be found for the indications of the above-mentioned Commission how inferences may be drawn from the extract.

"Wines prepared exclusively from pure grape-juice rarely contain quantities of extract which fall below 1·5 *grm.* in 100 *cc.* Hence wine poorer in extract is objectionable if it contains a smaller proportion, unless it can be shown that there occur natural wines of the same season, and from a similar position, with as low a proportion of extract."

This last sentence often furnishes the defence with a much desired way of escape, since proof is advanced of the previous occurrence (under the most unfavourable conditions conceivable) of the production of a similarly wretched wine.

"Without the deduction of the non-volatile acids, the residual extract in natural wines amounts, according to present experience, to at least 1·1 *grm.*, and, after such deduction, to at least 1·0 *grm.* in 100 *cc.* Wines

[1] One pfennig = $\frac{1}{100}$ part of a shilling.

showing smaller residual extracts are to be condemned, unless it can be shown, &c., as above.

"A wine which contains mineral matter to the extent of decidedly more than 10 per cent. of the residual extract must accordingly contain more extract than was otherwise assumed as the minimum. In natural wines there very frequently occurs a proportion approaching one part by weight of mineral matter to ten parts by weight of extract. A well-marked deviation from this proportion does not, however, at once warrant the conclusion that the wine is falsified."

5. The proportion of glycerine in pure wines fluctuates very considerably; according to § 384, from 0·3 to 1·38 per cent. As, however, it is a bye-product of fermentation, it bears a certain proportion to the percentage of alcohol.

"The proportion between alcohol and glycerine may fluctuate in natural wines between 100 parts by weight of alcohol to 7 parts by weight of glycerine, and 100 parts of alcohol to 14 of glycerine. In wines which show a different proportion, the addition of alcohol or of glycerine is to be inferred. As in the cellar manipulations, small quantities of alcohol (at most, 1 per cent. by volume) may find their way into the wine, this circumstance must be taken into consideration in forming a decision."

If alcohol and glycerine have been added simultaneously, the detection is almost impossible, as we have no means for a sufficiently accurate determination of the succinic acid which is formed simultaneously during fermentation. Even if we could do this the falsifiers would add succinic acid just as they now artificially increase the proportion of phosphoric acid.

An addition of glycerine, as it can be practically applied, should not be pronounced hurtful, for even if large quantities of undiluted glycerine, taken at once, act as a purgative, say from 15 to 30 *grm.*, and if very large doses have an action resembling that of alcohol, there is no doubt that the addition of a few grammes of glycerine (about 5 *grm.* per litre) are perfectly harmless in such dilution. Experiments on the guinea-pig—a very susceptible animal—prove that ½ *grm.* daily per kilogramme can be mixed with the food without injury. But the idea of consuming added glycerine excites disgust in the majority of persons. This disgust is increased by the representation that much glycerine is obtained from the fat of beasts which have died of disease.[1]

[1] This representation is, of course, not quite accurate. The number of such

6. Wines with a total acidity of 1·1 to 1·3 per cent. or upwards are unfit for drinking; they taste unpleasantly, and very often occasion diarrhœa. They keep badly, as they contain only 5 to 6 per cent. of alcohol. Such wines are fit only for the manufacture of vinegar, or they might have been gallised when in the state of must.

"The quantity of free tartaric acid in natural wines amounts to not more than one-sixth of the total non-volatile acids."

Larger quantities of free tartaric acid may generally be traced to the use of unripe grapes, or the addition of tartaric acid to the diluted and fortified wine.

Tartaric acid in general in the form of acid potassium tartrate or tartar, is never absent in wine, as are also malic and succinic acids, and to a slight extent citric acid.

As regards the proportion of acetic acid, the Commission for the Statistics of Wine at Carlsruhe in 1890 resolved that white wine containing 0·080 per cent., and red wine with 0·120 per cent. of acetic acid, are to be pronounced "inclining to sourness," whilst white wine with 0·120 per cent., and red wine with 0·160 per cent. of acetic acid, are spoiled, and no longer fit for consumption.

7. A proportion of tannin not too low is desirable. On the one hand (according to Nessler), it renders the wine more capable of resisting schizomycetes; secondly, the tannin is the essential factor for the medicinal dietetic action of red wines. In red wines 0·25 per cent. is a high, and 0·1 per cent. a low proportion; white wines usually contain only about 0·01 per cent.

8. An addition of water[1] will not easily act injuriously

beasts is small as compared with those slaughtered, and a very large and increasing proportion of the glycerine procurable is obtained from vegetable fats, especially palm-oil.—*Editor.*

[1] Here it may be mentioned that, as in the case of milk, the presence of nitric acid assists in betraying the presence of water.

If the percentage of nitric acid in the water used was low the simplest form of the test is sufficient. White wine is decolorised by shaking up with animal charcoal (free from nitric acid), and red wine with basic lead acetate and magnesium sulphate. The clear filtrates are allowed to flow into concentrated sulphuric acid, in which about 0·01 *grm.* diphenylamine per 100 *cc.* has been dissolved. 1 *mgrm.* N_2O_5 in 100 *cc.* of wine gives a distinct blue coloration. In utilising the results care is necessary, as the casks, &c., have to be rinsed with water. If such water is very rich in nitric acid a demonstrable quantity of nitric acid may be introduced into the wine. On the other hand, slight quantities of nitric acid disappear from wine in time.

upon health, as any poisons contained in the water will be strongly diluted, and the majority of pathogenic schizomycetes will be rather speedily destroyed. Still the possibility is admitted that an addition of unwholesome water might render wine injurious to health.

9. *Ash.*—"Universally valid limits for the several mineral matters cannot be assumed. The supposition that the better growths of wine always contain more phosphoric acid than the inferior sorts is unfounded."

"Wines which contain less than 0·14 mineral matter per 100 *cc.* are to be condemned, unless it can be proved that natural wines from the same position, and of the same season, which have been submitted to the same treatment, are found with similarly low quantities of mineral substances."

"Wines which contain more than 0·05 *grm.* sodium chloride in 100 *cc.* are to be condemned. The proportion of chlorine in pure wines varies from 2 to 6 *mgrm.* in 100, corresponding to from 3 to 10 *mgrm.* of sodium chloride. Clarifying ingredients rich in salt, well-waters abounding in salt (and therefore in general greatly polluted), and the intentional addition of salt (in order to increase the ash), are to blame for the high percentage of sodium chloride. Hence such a proportion of salt is often the indication of a composition which is hygienically objectionable. The proportion of phosphoric acid rarely falls below 20 *mgrm.* for 100 *cc.* in pure wines.

"Wines which contain more than 0·092 *grm.* sulphuric acid (SO_3), corresponding to 0·20 *grm.* potassium sulphate (K_2SO_4), in 100 *cc.* are to be characterised as having become too rich in sulphuric acid, whether by plastering or in some other manner, *e.g.*, strong and often repeated sulphuring (§ 233)."

Though a proportion slightly exceeding 2 *grm.* potassium sulphate per litre may perhaps be tolerated without injury by the majority of persons, the view taken in this resolution must be strongly approved and supported on hygienic grounds.[1]

[1] It must be remarked that if judged by this rule numerous old wines, certainly not plastered but frequently sulphured, would have to be condemned. Thus List has repeatedly found 0·77 to 0·89 *grm.* SO_3 per litre in wines from the cellars of palaces, and in older wines (1783 to 1822) several times from 1·3 to 1·5 *grm.* SO_3. The former figures would represent nearly 2 *grm.*, and the latter about 3 *grm.*, potassium sulphate per litre. These were wines famed as genuine medical wines. Compare E. List, *Ueber den Schwefelsäuregehalt des Weines in* 6 *Vorträge aus dem Gebiete der Nahrungsmittelchemie*, Würzburg, 1883.

Marty, in a communication to the Académie de Médec., stated that after the prolonged use of wine containing 3·8 *grm.* (= 1·74 SO_3) potassium sulphate per litre, he felt unwell. The symptoms were discomfort, acid eructations, and colic.

10. Sulphurous and salicylic acids are to be judged according to §§ 228 and 229. Large doses of sulphuric acid, and the presence of salicylic acid, always suggest that we have before us a product of poor keeping properties, which may, perhaps, have already been in a state of incipient decomposition. (See §§ 234 and 235.)

11. Vegetable colouring-matters are almost all hygienically inert;[1] none of the plants yielding colouring-matters is hurtful with the exception of *Phytolacca decandra*—the fine blackish violet berries of this plant, which is often cultivated in the South for the purpose of colouring wines. Children have frequently, after eating them, been attacked with vomiting and diarrhœa. Maqui-berries are used in their native country for the manufacture of jams, and seem therefore harmless.

12. Red coal-tar colours are probably for the most part harmless; but as some of them may be injurious, and as their use is unattended with any advantage, they are rightfully prohibited. As cheap waste colours, manufacturing residues, &c., have been in use, and perhaps still are, it is pointed out that the harmlessness of the pure colours by no means involves the harmlessness of these waste products; a proportion of arsenic was formerly frequent. (See § 494, &c.)

If we finally sum up the decision of hygiene on the most important methods of improving and increasing wine, and on the manufacture of artificial wines, we must say that the addition of water, sugar, alcohol, moderate quantities of glycerine and vegetable colouring-matters (mallows, bilberries, elder-berries), cannot be regarded as unwholesome as long as—

1. The product obtained is sound, capable of keeping, and not too rich in alcohol.

[1] Runge proposed the law that every pure vegetable colouring-matter is physiologically indifferent.—*Editor.*

2. The additions themselves are not contaminated; at most the addition of glycerine might perhaps be regarded as objectionable.

Impure water, impure spirit, impure potato-sugar, artificial colouring-matters, the addition of bouquet materials, render wine suspected of unwholesomeness. If such hurtful properties do not always exist, if they are not always capable of demonstration, or if, as in the case of potato-sugar, they have been greatly exaggerated, hygiene must nevertheless, on principle, condemn the use of such substances, as they may occasion derangements of health, and as there is no ground for their permission.

APPENDIX I.—SOUTHERN WINES, SWEET WINES, AND MEDICINAL WINES.

§ 402. As "southern wines" we meet with wines from the sweet grapes of semi-tropical regions. The concentration of the must is further increased by the use of raisins, "straw-grapes,"[1] &c. According to List we may conveniently distinguish:—

1. *Dry Wines* (vino seco), poor in sugar (containing not more than ½ per cent. of sugar), rich in alcohol, and generally poor in glycerine; obtained by the rapid fermentation at a high temperature of the grapes of southern climates, and having undergone at most a moderate addition of alcohol.

2. *Sweet Wines* (vino dulce). Wines from southern grapes, to which there has been added after fermentation the inspissated must of sugary grapes, or the sweet juices of other fruits, such as dates, figs. &c. At the same time they often receive an addition of pure spirit, of cognac, liqueurs, and often of colouring-matters, such as inspissated scorched must, elder-berries, &c. Such wines contain from 4 to 15 per cent. of reductive sugar; the difference of extract minus sugar must amount to at least 4 *grm.*, and the phosphoric acid 40 *mgrm.*, in 100 *cc.*

The Hungarian wines of the first pressing (*i.e.*, Tokay) are obtained from grapes rich in sugar, to which there are added during pressing large quantities of dry grapes (*i.e.*, raisins which have been left on the vines).

In many cases bungling imitations of the genuine sweet wines are concocted from inferior southern or Hungarian

[1] *I.e.*, grapes plucked and spread out on straw in the sun.

wines by an addition of alcohol, cane- or invert-sugar, and sugar-colour; but recently cane-sugar is often added, even to the superior southern wines, instead of the more costly inspissated must or of raisins.

A decision on such wines concerns the hygienist only when they are offered for sale as medicinal wines; as dessert wines, beverages of luxury, they do not concern the hygienist, as even the most wretched imitations can scarcely occasion any injury to health, and may be consumed with pleasure by those who like them.

It is not easy to say what demands are to be made upon wines which are declared on the labels to be "medicinal wines," since wine may be prescribed for very various purposes (*e.g.*, as stimulans, as antidiarrhoïcum, &c.). For many purposes the alcohol is the most important ingredient, and for others the tannin; sugar is often very welcome (agreeable taste), and often very unsuitable (in various affections of the stomach). The demands of the Free Association of Bavarian Chemists appear very suitable, as rendering it more easy for the physician to make a selection among the different kinds:

1. Medicinal wines may not contain more sulphuric acid than corresponds to 1 *grm.* potassium sulphate per litre (compare § 401). As much as 4 *grm.* potassium sulphate have been found in southern medicinal wines.
2. Medicinal wines must contain no sulphurous acid.
3. In medicinal wines the proportion of sugar and alcohol must be given on the labels of the bottles in percentages of weight; it may be desirable to know the acidity, and in red wines the proportion of tannin.

Hence it appears perfectly permissible to use for medicinal purposes native (*i.e.*, German) wines of known quality, in which no great acidity must be present, not above 0·6 per cent. See Von Kerschensteiner, Fifth Meeting of Bavarian Chemists, 1887, pp. 59 and 60.

At the Ninth Congress of Bavarian Chemists, just concluded, medicinal wines are defined as "wines employed in preparing medicines" (*Chemiker Zeitung*, 1890, No. 42). It

would be greatly to be regretted, from a hygienic point of view, if the strict requirements laid down for wines sold especially for the use of sick persons were not retained, especially the third stipulation.

To consider champagne and effervescing wines would take us too far. On their hygienic meaning nothing of any consequence can be said, save that the high percentage of sugar, and perhaps the excessive addition of flavourings, may interfere with the wholesomeness of some brands.[1] See F. List, *Die Schaumweine* (Eighth Congress of Bavarian Chemists at Wurzburg, 1889).

APPENDIX II.—INITIAL POINTS FOR EXAMINING SPOILED WINES, WINES OF ABNORMAL ODOUR AND TASTE, AND WINES ENGAGED IN FERMENTATION.

§ 403. In examining if a wine is spoiled or not, in very many cases the taste and smell on careful observation will suffice, even for a non-expert. Hitherto, indeed, the following typical diseases of wine are known, which are all to be referred to microbia as yet insufficiently studied.

I follow here E. List, who at the Sixth Congress of Bavarian Chemists at Munich, 1887, gave a survey of the position of the question, with further literary notices.

The bacteriological investigation should be attempted with wine-gelatine (1 litre wine and 100 gelatine, &c.), or with wine which has been rendered free from microbia by filtration through cells of biscuit porcelain.

1. Formation of mould by saccharomyces (*Mycoderma vini*, Pasteur; *Saccharomyces mycoderma*, Rees). Flourishes especially on the surface of wines poor in alcohol; the complete layers sink to the bottom, and make room for new strata. Ferments alcohol into CO_2 and water. A proportion of 11 to 12 per cent. of alcohol is a protection against this microbe. The wine tastes flat.

2. *Acetic Fermentation* of alcohol by *Bacillus aceticus*, a very short

[1] It will be remembered that in most parts of the Continent champagne is purely a dessert-wine, and that the dry qualities are much less sought after than in Britain.—*Editor.*

bacillus, sometimes hanging together like a necklace, forming thick layers, but imperfectly studied. It is even capable of attacking wines containing 12 per cent. of alcohol. This process, which leads to an absolute destruction of the value of the wine, can be arrested only by pasteurising. The presence of 0·05 per cent. of acetic acid does not interfere. It occurs not rarely in southern red wines. For the acetic acid microbia see Zeidler (*Centralblatt f. Bakteriologie*, ix. 10).

3. *The Breaking or Inversion of Wine.*—The tartaric and malic acid, the tannin and the colouring-matter are destroyed, and the alcohol disappears. The colourless liquid contains chiefly potassium carbonate, along with a series of volatile fatty acids. In this process, according to Pasteur, two species of microbia are concerned. E. Kramer (*Landwirthschaftliche Versuchstationen*, xxxvii., p. 325) detected seven bacilli and two cocci, for the study of which the original must be consulted.

4. In the ropiness of wines the sugar of new wines passes into a gummy substance.

Kramer has recently published some remarks on the bacillus which occasions the mucic fermentation of wine (at the expense of the glucose), *Bacillus viscosus vini*, Kramer (*Monatshefte für Chemie*, 1889, p. 467). It is a short bacillus, often linked together in long chains. A distinct form is the *Bacillus viscosus sacchari*, Kramer, which succeeds only on neutral or slightly alkaline media containing cane-sugar; again distinct is the micrococcus of ropy milk (§ 285).

5. The bitterness of red wines seems to be occasioned by a bacillus. Even old wines become bitter in the bottles. (See Haas, *Allgem. Wein Zeitung*, 1891, p. 4.)

Moreover, wines, especially such as have been already deprived of their alcohol by one of these micro-organisms, may be further decomposed by hyphomycetes and septic organisms.

In all these diseases the colour is usually altered. Red wines especially become brownish, turbid, and even colourless.

Blackening of wine[1] occurs also if wine comes in prolonged contact with rusting iron (nails, the hoops of casks). If the wine is slightly acid, black iron tannate is precipitated at once; if it is strongly acid, blackening takes place only on neutralising the acid, *i.e.*, on admixture with soda-water (sodium bicarbonate).

Wine may from various causes assume the taste and smell of sulphuretted hydrogen, *e.g.*, by absorbing sulphur compounds from the soil, by standing for a long time on lees sprinkled with powdered sulphur, or in casks into which sulphur has fallen during fumigating, by the activity of saccharomycetes, and lastly, by the putrefaction of the residual dregs in the cask.

In how far these diseases of wine may render it unwhole-

[1] Subsequent darkening of white wines on exposure in a glass for some hours may be either a sign of the use of over-ripe grapes or of piquette. It has no hygienic importance.

some to man is scarcely yet known. In any case they render it worthless as an article of enjoyment, and should therefore at once exclude it from sale. Nos. 1 and 2 are mostly commonly observed, but also the other diseases are often a great plague in many districts. Deficiency of alcohol, the use of rotten grapes, prolonged fermentation on the skins, warm cellars, premature bottling, &c., are the most frequent causes of the decompositions of wine. The presence of sulphuretted hydrogen is generally difficult to decide on, but it must be regarded as much more serious if it is due to processes of putrefaction. Blackening in consequence of the presence of iron is in itself not hygienically objectionable; but wine will probably not keep as well if its tannin is in combination with iron.

The clarification of dull wines with gelatine, isinglass, or albumen (if needful, with the judicious use of tannic acid), which form a voluminous precipitate and carry down all suspended matter, must be pronounced hygienically free from objection; clarification with blood or milk is less rational. Blood may possibly introduce pathogenic microbia (the bacilli of tubercle remain alive for three days in alcohol at 46 per cent.); milk is said to have introduced lactic fermentation.

APPENDIX III.—FERMENTING MUST AND FERMENTING NEW WINE.[1]

§ 404. Whilst fresh unfermented grape-juice is drunk only in the so-called grape-cure, the fermenting must, in all stages of its development, plays an important part as a delicacy in all the wine countries. It is rich in carbonic acid and turbid from accumulations of yeast; its composition is intermediate between those of wine and of must, and the proportion of alcohol fluctuates greatly. The ingestion

[1] Two German synonyms—"Federweisser" and "Sauser"—do not admit of intelligible translation. "Federweisser" literally means something white, like feathers or down. "Sauser" = buzzer or hummer, from the buzzing noise made by the fermenting must.

of yeast is evidently as a rule harmless (§ 378). Among the new points of view considered in the examination of and the decision on wine, it must be remembered that fermentation is often forcibly repressed by strong doses of salicylic or sulphurous acid.

APPENDIX IV.—FRUIT-MUST AND FRUIT-WINE.

§ 405. Pleasant and even fine beverages are obtained from apples (cider), from pears (perry), and in many places also from currants,[1] gooseberries, and bilberries, with or without the addition of sugar. (For the analysis of these liquors see Table X.)

Without the addition of sugar to the apples no cider can be obtained which will remain good for more than two years. The addition of sugar to the must, or of alcohol to the wine, are necessary if the wine is to remain sound.

Pure cider contains about from 3·6 to 6·1 per cent. of alcohol, and a proportion of 10 per cent. renders it perfectly fit for keeping. (See Von Hoffmann, *Vierteljahr. f. Ger. Medicin*, 1890, p. 115.) The examination and the hygienic decision are substantially the same as for wine.

Mixtures of grape- and fruit-wines are said to be often sold as wine. This fraud does not concern hygiene.

APPENDIX V.—VINEGAR.

A. Examination.

§ 406. Vinegar is essentially acetic acid at 3 to 8 per cent. (generally 4 to 5 per cent.), containing a little acetic ether, and diluted with water. Various other ingredients are added during preparation. We distinguish three kinds of vinegar:

1. Obtained from alcoholic liquids by the acetic fermentation. The alcohol in wine, beer, cider, &c., under certain circumstances is converted into acetic acid by the *Bacillus aceticus* (§ 403).

[1] We have tasted red currant wine which had been in bottle twenty years, and was in excellent condition, far superior to the "British wines" of commerce.—*Editor.*

Vinegar thus obtained always contains tartrates, acetates, phosphates, &c., which on ignition leave an alkaline ash.

Only wine-vinegar contains potassium tartrate, but tartaric acid is sometimes intentionally added to spirit-vinegar which is to be sold as wine-vinegar.

2. Produced by the quick vinegar process. Dilute alcohol in contact with air trickles over shavings of beech-wood, and is converted into acetic acid, perhaps with the joint action of microbia. Thus a strong vinegar is produced (spirit-vinegar), containing from 8 to 10 per cent. of acid, which is sold in a diluted state. It contains salts only to a small extent.

3. Obtained by the dry distillation of wood. The brown, crude wood vinegar has an empyreumatic odour. When carefully rectified it yields a very pure acetic acid (essence of vinegar) of about 70 per cent., from which cheap vinegar is obtained. Salts are introduced merely to a slight extent by the water used for dilution.

The strength of vinegar is ascertained by titration with normal soda-lye, using phenolphthaleine as indicator. To each cubic centimetre of lye there corresponds 0·06 *grm.* of acetic acid. Hence, if for titrating 20 *cc.* of vinegar (strictly speaking, 20 *grm.*) there have been used 12 *cc.* normal lye, of this portion 0·72 *grm.* or 100 *cc.* vinegar contain 3·6 *grm.* acetic acid.

Falsifications of vinegar with sulphuric and hydrochloric acid have occurred, and, it is alleged, also with nitric acid.[1] The addition of tartaric acid, which is more expensive than acetic acid, serves merely to simulate wine-vinegar.

Free mineral acids are detected by adding from 4 to 5 drops of a 0·1 per thousand solution of methyl-violet (Stockmeier recommends the mark $B_2N.56$, by Bayer, of Elberfeld). If only from 0·1 to 0·05 per cent. of a free mineral acid is present, the violet colour passes into a bluish green or green; in pure acetic acid there occurs no change of colour. According to Lunge a few drops of a solution of tropeoline (Mark OO) colour pure vinegar yellow, but red if free mineral acids are present.

For the quantitative determination of the free mineral acids we proceed according to Hilger (*Arch. f. Hygiene*, viii. 448): 20 *cc.* of the vinegar in question are exactly neutralised with normal alkali by

[1] The presence of nitric acid in vinegar is very doubtful.—*Editor.*

means of the "spotting" method; the neutral liquid is concentrated on the water-bath to the tenth part of its volume, mixed with a few drops of the solution of methyl-violet, diluted with water to about 3 to 4 *cc.*, and mixed, whilst hot, with normal sulphuric acid until the change of colour (violet into green), which is very distinct. The normal sulphuric acid consumed is deducted from the normal alkali, and the residue of normal alkali is calculated for the mineral acid present. 1 *cc.* normal alkali = 0·049 *grm.* sulphuric acid (H_2SO_4).

Example.—20 *cc.* of vinegar consume 14·15 *cc.* of normal alkali. After the concentration with methyl-violet as indicator, there are consumed 13·3 *cc.* of normal sulphuric acid. The difference is 0·85 *cc.* normal alkali. Therefore in 20 *cc.*: 13·3 × 0·06 = 0·798 acetic acid, and 0·85 × 0·049 = 0·042 *grm.* sulphuric acid, or 3·99 per cent. acetic acid and 0·2 per cent. sulphuric acid.

A little hydrochloric and sulphuric acid are found in every vinegar in the state of salts; a quantitative examination is in general thought requisite only if free mineral acids are detected.

If vinegar has still a pungent taste, and is not flat after exact neutralisation, it contains a fraudulent addition of acrid vegetable matter: pepper, capsicum, grains of Paradise, &c. Vinegar has been met with containing 1 per cent. of amylic alcohol, and with appreciable quantities of cresolic acid.

B. Decision.

§ 407. Without any appreciable nutritive value, vinegar is an important relish for food, and it is extensively used as a preservative agent. The three kinds of vinegar described may be regarded as nearly equal from a hygienic point of view. Wine-vinegar is justly valued more highly, as it contains traces of compounds of a pleasant odour and flavour.[1]

Vinegar with only from 1 to 2 per cent. of acetic acid, as occasionally happens, is to be condemned as inferior in value, not capable of keeping, and unfit for the purposes of preservation. The Bavarian food-chemists rightly demand

[1] The cider-vinegars of America, and the sugar- and honey-vinegars made on the small scale in England, have a very similar aroma. On the other hand, the spirit- and the wood-vinegars, the beer-vinegars—provincially called "alegar"—and even the malt-vinegars so much vaunted in England, however strong and free from adulteration, are deficient in aroma. The question has been raised whether the presence of dextrine may not interfere with the production of esters.—*Editor.*

4 per cent. of acetic acid as a minimum. Concerning an injurious action of *Anguillula oxyphila* (vinegar-eels), nothing trustworthy is known. The worms, from 1 to 2½ *mm.* in length, which are often found in extraordinary abundance, especially in weak vinegar, render it disgusting. Lindner (*Centralblatt f. Bakteriologie*, vi.) has recently attempted to render the injurious character of the vinegar-eels probable in an extensive memoir, but without real evidence.

Free mineral acids have no right to be present in vinegar, and represent a coarse sophistication. Still I do not feel at liberty to pronounce an addition of from ½ to 1 per cent. of mineral acid directly injurious to health. That powerful acids may occasion disturbances of the stomach is well known, just as may result from the use of strong vinegar. The mineral acids in very low degrees of concentration may be more pernicious than acetic acid, but it is scarcely satisfactorily proved.

The acid substances commonly used rank among our ordinary spices, and must be judged as such. The use of substances whose effects are not accurately known, *e.g.*, the berries and the bark of the mezereon, must of course be condemned, as under some circumstances dangerous to health.

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SECTION XV.

BRANDIES FOR DRINKING AND CHOICE SPIRITS.

§ 408. The various brandies and liquors are obtained by the distillation of fermented liquids from saccharíferous portions of plants (cherries, damsons, gentian roots, &c.), but more simply by diluting alcohol with water, and adding aromatic substances, ethereal oils, sugar, colouring-matters, &c.

The spirit of commerce (industrial alcohols of the French) is obtained in Germany from potatoes, more rarely from grain (rye, maize),[1] by saccharifying the boiled materials with malt (§ 365), fermenting them by means of yeast, and distilling off the alcohol. With the improved distilling apparatus now in use a crude spirit is at once obtained containing about 90 per cent. of alcohol. The alcohol is defuselised in general in special rectifying works, *i.e.*, it is mixed with an equal volume of water, filtered over fresh wood-charcoal, and then submitted to fractionated distillation. The first running consists principally of aldehyde, then follow grades of ethylic alcohol of different purity, the two best of which are known as wine-spirit and fine-spirit; time and second spirit are inferior sorts, and the last product of distillation is the after-running. Crude potato-spirit contains as much as 3 per cent. of fusel oil, under which name are included all the volatile products other than aldehyde, ethylic alcohol, and water. The finest sorts of spirits are free from fusel oil. The lowest contain 1 per cent., or even more. The after-runnings are very rich in fusel. Spirit for burning may occasionally contain as much as 10 per cent. of fusel-oil.

[1] In Britain alcohol is chiefly obtained from malted barley, and in America from maize.—*Editor.*

Rabuteau obtained in 1878, on the analysis of 1 litre of fusel oil, from potatoes:—

	Cubic Centimetres.
Isopropylic alcohol	150
Primary propylic alcohol	30
Ordinary butylic alcohol	50
Normal butylic alcohol	65
Secondary amylic alcohol (methyl propyl carbinol)	60
Ordinary amylic alcohol (isobutyl carbinol)	275
Products boiling above 132°, and containing amylic alcohol	170
Water	125

Single brandies contain from 20 to 38 per cent. by volume of alcohol, and are obtained by the addition of water to ordinary alcohol; more frequently they are rectified over carraway, aniseed, fennel, or juniper berries, from which they take up the ethereal oils. Often the latter are added directly.

Double brandies contain about 36 volumes per cent. of alcohol, and about 13 per cent. of sugar, along with aromatic substances.

Corn brandy is a spirit from a mash of grain intentionally not completely rectified, and diluted with water. Its colour is partly extracted from the wood of the casks on lying, and partly produced by the addition of burnt-sugar. It is often got up by adding strongly fuseliferous corn brandy of a characteristic taste to potato-spirit[1] poor in fusel.

Kirsch wasser (cherry brandy), maraschino (from the fruits of *Prunus mahaleb* and mountain ash), spirit prepared by distilling the fermented fruits, contain from 0·005 to 0·01 per cent. of hydrocyanic acid.

Lees-spirit is obtained by distilling the residue from the preparation of wine. Cognac (French brandy) is produced by distilling the wine itself.

Cognac contains about 60 per cent. by volume of ethylic alcohol, and it is exposed to the most multifarious imitations, especially by the addition of "cognac essence" (an artificial

[1] Corn brandy makes the nearest approach to whiskey, but it is a very inferior spirit.—*Editor.*

mixture of fruit-ethers to fine-spirit and water). Genuine cognac comes from the Charente, especially from the town Cognac, but cognac is now also manufactured in Germany, and in other countries.

According to the researches of Pasteur, Morin, and Ordonneau, cognac is chiefly distinguished from the industrial alcohols by its large percentage of normal butylic alcohol. The industrial alcohols contain in its stead isobutylic alcohol, which has a much less pleasant taste. In cognac there are also found aldehyde, acetic ether, acetone, normal propylic alcohol, amylic, hexylic, heptylic alcohols, the propionic, butyric, caprylic, and œnanthic esters and amine bases. A terpene very sparingly volatile is also a condition of the flavour.

Rum is obtained from the fermented treacle, and the residues of the sugar-cane and *arrac*, chiefly from a mash of rice.[1] The preparation of these exotic spirits is often insufficiently known; the addition of various flavouring-matters is very general.

All the above-named superior spirits contain higher alcohols of a pleasant flavour, but in part still little known. In consistency, science is compelled to include these substances under the name of fusel oils.

Liqueurs are either alcoholic extracts of plants, filtered or distilled, or fine-spirit perfumed with ethereal oils, almost always with a plentiful addition of cane-sugar, and often with colouring-matters. So-called health-liqueurs contain not uncommonly hazardous bitter drugs (aloes), but more generally they are harmless, sweetened extracts of orange-peel, rhubarb, bitter drugs, calamus, spices, &c.

§ 409. All these spirituous liquors are conveniently divided into two groups: draught-brandies and spirits which are luxuries. The first category only is consumed to such an extent, and in such quantities, that practical hygiene can take closer cognisance of its composition. The unlimited variety renders it further very difficult to establish fixed rules for the spirits of luxury.

[1] Genuine arrac should be distilled from the fermented juice of the cocoa-nut palm. It is, however, frequently distilled from rice and sugar, fermented with the cocoa-nut juice.—*Editor.*

A sharp boundary-line cannot be drawn between both groups, but for the present we may characterise as draught-brandies those intended for drinking on the large scale, which are indigenous, generally not sweetened, only slightly flavoured with ethereal oils (carraway, juniper, &c.[1]), and kept on draught. They consist generally of diluted potato-spirit, corn-spirit, or lees-brandy.

As spirits of luxury we must characterise those kept and sold in original bottles, imported or made from the finest native ingredients, generally sweetened, and more expensive.

We generally examine the draught-brandies only for the presence of injurious substances mixed with the alcohol. The luxury-spirits are examined only if they are *genuine* products, which has no hygienic interest. The following explanations apply only to draught-spirits. A few aphoristic remarks are appended on the spirits of luxury.

A. Examination of Draught-Spirits.

§ 410. The specific gravity is determined according to § 369. In ordinary spirits, containing neither sugar nor vegetable extractive substances, we may ascertain the percentage of alcohol from the specific gravity with tolerable accuracy by means of Table XVI.

It is generally expressed in volumes per cent., *i.e.*, x *cc.* alcohol in 100 *cc.* of spirit. The recalculation to grammes in 100 *cc.* is effected by multiplying the x found by 0·7938 (the specific gravity of alcohol).

The determination of alcohol, however, must in general be preceded by distillation as for wine (§ 388). The ethereal oils and ethers which pass over into the distillate are so trifling in quantity as not to affect the accuracy of the result. If a determination of fusel oil is performed, it may accompany the determination of the alcohol.

The dry residue and the ash are determined as for wine (§§ 389 and 398). The sugar (fruit- and grape-sugar) are determined directly,

[1] "Doppel kümmel" is the favourite dram of the lower classes in many parts of Germany. Juniper approximates to gin, or rather to "Geneva."—*Editor.*

and the cane-sugar after inversion with acid. Copper is sought for colorimetrically with a freshly prepared solution of potassium ferrocyanide. It may be derived from the distillery plant.

Ammonia, nitric acid, and nitrous acid, which may be introduced into spirits by bad water, are detected according to §§ 194, 181, and 183.

Sulphuric acid, or minute quantities of ammonium hydrocyanate, is sometimes added to spirits to make them "bead" better. Free sulphuric acid is determined in the residue from distillation, according to § 406. The ash must also be tested for alumina, since alum is sometimes used for clarifying. According to Sonnenschein alum is said to remove the smell of fusel.

For the determination of hydrocyanic acid 10 *cc.* of spirit are carefully superstratified with 1·5 *cc.* of recently prepared tincture of guiacum (from one part of guiacum resin, and five parts alcohol) and solution of copper sulphate at ½ per cent. The liquids are then suddenly mixed, and the intensity of the blue coloration is measured against comparative liquids obtained by adding officinal bitter-almond water of a known strength of hydrocyanic acid to 50 per cent. alcohol in different proportions. Officinal water of bitter almonds contains exactly 0·1 per cent. hydrocyanic acid HCN.

Nitro-benzol.—If we suspect that an odour of bitter almonds is derived from nitro-benzol instead of from oil of bitter almonds (benzo-aldehyd), we add to about 50 *cc.* some zinc and mineral acid. It is better to distil away the chief portion of the alcohol from about 200 *cc.* of the spirit and examine the residue. By means of reduction with zinc and hydrochloric acid aniline is formed, which may be separated by rendering the mixture alkaline with soda-lye, and then shaking out the mixture with ether. If a splinter of pine-wood moistened with dilute sulphuric acid is dipped into the aniliniferous liquid it takes on drying an intense yellow colour. Aniline takes a rose-violet colour with a solution of chloride of lime.

If an addition of *denaturised spirit*[1] is suspected (the official prescription being 2½ litres of a mixture of four parts wood-spirit and one part of pyridine to 100 litres of alcohol), it is better to test for the pyridine bases (Schweissinger, *Pharm. Centralhalle*, 1890, p. 141) rather than for methylic alcohol, the detection of which is difficult and uncertain. 10 *cc.* of the distillate is mixed with ten drops of a concentrated (20 per cent.) solution of mercuric chloride, shaken up and allowed to subside. To a second similar test we add further 10 *cc.* of pure alcohol, and as a counter-check there are used quantities of alcohol of 10 *cc.*, each mixed respectively with 0·5 and 0·25 *cc.* of the denaturised spirit. There appears a white precipitate, or at least a turbidity of mercuric chloride pyridine ($HgCl_2 . C_5H_5N$). In this manner 5 per cent. of denaturised spirit (= 0·025 per cent. of pyridine) may be detected with certainty. An addition of 1 per cent. of denaturised spirit to draught-spirits is very distinct and unpleasant to the taste.

[1] Spirit rendered unfit for drinking by means of certain additions.—*Editor.*

§ 411. *Fusel Oil.*—A preliminary test for the presence of fusel oil can be made by rubbing a few drops of the alcohol on the hands and examining the smell. The brown colour on heating with concentrated sulphuric acid and various ingenious methods proposed by Uffelmann (*Arch f. Hygiene*, iv.), are, according to Sell, not free from ambiguity, and may therefore be passed over.

For the determination of fusel oil various methods have been proposed. The most convenient is that of Röse, which is now in general use.

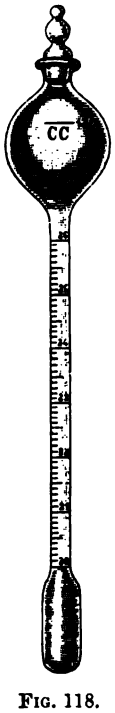

FIG. 118.

Röse's Apparatus for the Determination of Fusel Oil.

Principle.—If pure chloroform is shaken up with alcohol at 30 per cent. by volume, the volume of the chloroform is increased by taking up alcohol. If higher alcohols are present, even in very moderate proportion, the increase in the volume of the chloroform is rather considerable, and from the degree of this increase the percentage of the higher alcohols may be deduced.

Execution.—(According to Sell, who has most thoroughly studied the method of Röse as improved by Stutzer and Reitmair):—

Of 200 *cc.* of spirit, measured at 15°, to which a few drops of potassa-lye have been added, four-fifths are distilled off with an ascending condensing-tube (Fig. 85) and good refrigeration. The distillate is made up exactly like wine, at 15° to 200 *cc.*, with distilled water, and the specific gravity is determined. Hereupon we find in Table XV. the proportion of alcohol in percentages by volume (v), and calculate how much water (x) must be added to 100 *cc.* of the distillate in order to obtain an alcohol of 30 per cent. by volume.

$$100 + x : v = 100 : 30.$$

$$x = \frac{10v - 300}{3}$$

The distillate will rarely be weaker than 30 per cent., when a cubic centimetres of absolute alcohol are to be added:

$$100 + a : v + a = 100 : 30.$$

This addition of water (or of alcohol) is effected gradually in a large flask, shaking vigorously, and cooling down to 15°. After the mixture we ascertain whether at 15° the specific gravity of the 30 per cent. alcohol 0·9656 has been exactly reached.

We now introduce into the apparatus here shown, which is introduced into water at 15°, 20 *cc.* of the purest anhydrous chloroform cooled down to 15°. It is allowed to flow in from a pipette without touching the sides of the apparatus until the lower meniscus of the chloroform coincides with the mark 20; 100 *cc.* of the 30 per cent. distillate are then added, and 1 *cc.* sulphuric acid of specific gravity 1·2857. 150 strong agitating shocks are then given, and the drops of chloroform clinging to the sides are then united to the chief mass, which has collected at the bottom by means of a rotatory motion after the apparatus has been again placed in water at 15°.

The present volume of the chloroform is increased, *e.g.*, to 21·90. By direct reading off from the following table, we find that the proportion of fusel oil in the alcohol in question $f = 0{\cdot}1724$ per cent.

TABLE FOR DETERMINATION OF FUSEL OIL.

Cc. Read Off.	Vols. of Fusel Oil per Cent.	*Cc.* Read Off.	Vols. of Fusel Oil per Cent.
21·64	0	22·00	0·2387
21·65	0·0066	22·05	0·2719
21·70	0·0398	22·10	0·3050
21·75	0·0729	22·15	0·3382
21·80	0·1061	22·20	0·3713
21·85	0·1393	22·25	0·4045
21·90	0·1724	22·29	0·4410
21·95	0·2055		

For each increase of 0·01 *cc.* the proportion of fusel rises by 0·0066 per cent.

The alcoholic distillate of 200 *cc.* of spirit, made up to 200 *cc.*, had been mixed with $2x$ *cc.* of water; then the actual percentage is:

$$f_1 = \frac{f\,200 + 2x}{200} = \frac{f(100 + 5)}{100}$$

If $2a$ *cc.* alcohol had been added, a must be inserted instead of x. If the proportion of fusel is to be calculated for 100 vols. of absolute alcohol, which is convenient for many purposes, we simply take:

$$f_2 = \frac{f \cdot 100}{30} = \frac{10f}{3}$$

It would take us too far to examine the influence of the numerous other constituents of the distillate—aldehyde, acetal, furfurol, ethereal oils, &c.—upon the quantitative result. We must here refer to Sell's exhaustive account. In ordinary draught-spirits the errors are not of great importance.

The ethereal oils in slight quantities occasion a small decrease of the volume of the chloroform, but in large proportions they cause an increase.

B. Decision on Draught-Spirits.

§ 412. As it is beyond doubt that especially the use of spirits, the richest in alcohol among our beverages, produces the most severe affections of chronic alcoholism, the question has been repeatedly raised whether the danger cannot be restricted by means of legislation. It is at present certain that especially the strong draught brandies are hygienically objectionable. Of 265 samples of "schnaps" examined from all parts of Germany—

23	contained	less than 30	per cent.	alcohol by volume.
24	„	from 30 to 35	„	„
94	„	from 35 to 40	„	„
81	„	from 40 to 45	„	„
31	„	from 45 to 50	„	„
9	„	from 50 to 78	„	„

Hygiene is not in a position to decide below what percentage a spirit ceases to be injurious, but it may demand that for draught-spirits a certain maximum percentage of alcohol should be laid down, *e.g.*, 40 per cent. by volume, as Bär proposes.

If unanimity prevails among hygienists on this first point, there is a second which is still disputed, *i.e.*, the question: In how far is the injuriousness of spirits determined by the presence of fusel oil? Whilst I must refer to Sell for the literature of this very difficult question, which, though exceedingly voluminous, is poor in large systematic works, I bring into prominence merely the following main points:—

1. Beyond doubt all the other alcoholic-ethereal constituents of spirits are more deleterious than ethylic alcohol.

Dujardin-Beaumetz and Audigé (*Bulletin gén. de Thérapeutique*, 1875) state that a dog quickly dies if it has in its stomach, per kilogramme of its own weight:

Ethylic alcohol	5·5 to 6·5 *grm.*
Or propylic alcohol	1·76 *grm.*
Or butylic alcohol	1·80 *grm.*
Or amylic alcohol	1·4 to 1·55 *grm.*

Accordingly amylic alcohol is four times more poisonous than ethylic alcohol.

Aldehyde is fatal to dogs in the proportion of 3·5 *grm.* per kilogramme of their weight. Aldehyde has an irritating taste and smell.

Brockhaus made experiments upon himself with aldehyde, acetal, propylic, isobutyric, and amylic alcohols, all of which were more unpleasant to take and more effective than ethylic alcohol. Unfortunately he states the doses taken only in drops. Ten drops of aldehyde, suitably diluted, occasioned intense irritation, produced dizziness and headache ; 100 drops of amylic alcohol in ½ litre of wine caused a strong burning and irritating sensation in the mouth, and brought on pains in the stomach, nausea, and inebriation. According to these experiments on a man accustomed to alcohol, the substances in question were far more than four times (rather from ten to twenty-five times) more poisonous than ethylic alcohol (*Centralblatt f. allg. Gesundheitspflege*, i. 1882, p. 146 .

Among the basic principles which Morin described in fusel oils, and which are said to be produced by the action of ammonia upon glycerine, 1 *grm.* per kilogramme of the weight of the animal is sufficient to kill a rabbit.

2. On the other hand, it cannot be said with certainty whether the quantities of fusel oils which occur in the majority of our draught-spirits (from below 0·2 to 0·3 per cent.) in reality appreciably intensify their hurtfulness. Of 256 samples at the "Gesundheitsamt," 33 were free from fusel, 106 contained from 0 to 0·1 per cent., 82 contained from 0·1 to 0·2, 29 from 0·2 to 0·3, and 6 from 0·3 to 0·5 per cent.

The experiments on the large scale instituted by Dujardin-Beaumetz and Audigé on pigs, and carried out almost for three years, showed with probability a slighter unwholesomeness in potato-, beet-, and grain-spirit, purified as completely as possible, and free from fusel, as compared with impure sorts ; but here also contradictory results were observed, so that the authors themselves do not regard their laborious results as decisive.

Among more recent results I may mention only those made by Strassmann (*Exper. Untersuchung zur Lehre vom chron. Alkoholismus. Viertelj. f. Gericht. Med.*, 1888) on twelve dogs with ethylic alcohol at 32 per cent. by volume, in which amylic alcohol was substituted for parts of the ethylic alcohol.

Newer experiments also by Strassmann (*Viertelj. für öffent. Gesundheit*, 1890, vol. xxii.) showed no especial toxicity of small admixtures of fusel oils as far as dogs are concerned.

Certainly $\frac{5}{4}$ *x cc.* of alcohol at 30 per cent. free from fusel was much more hurtful than *x cc.* of 30 per cent. alcohol containing by volume 0·4 per cent. of fusel.

An artificial "schnaps" with 29 per cent. ethylic alcohol and 3 per

cent. amylic alcohol proved fatal in half the usual time; a mixture of 31 per cent. ethylic alcohol and 1 per cent. of amylic alcohol caused intensification of many of the symptoms without accelerating death; a mixture of 31·7 per cent. of ethylic alcohol and 0·3 per cent. amylic alcohol produced no other effects than those of pure ethylic alcohol at 32 per cent.

Various inquirers have also experimented on man.

Zuntz (in Sell, p. 347) seeks to refer the unpleasant action of fusel to its disagreeable smell and taste. He took for a considerable time doses of from 1 to 1½ *grm.* fusel in gelatine capsules without effects (corresponding to from 200 to 300 *grm.* of unusually fuseliferous brandy), and contends warmly that the action of spirits are so deleterious, especially because the people who consume it are not as well nourished as beer and wine drinkers. Zuntz considers admixtures of 0·3 to 0·4 per cent. of fusel not markedly injurious.

However, the question of the toxicity of the fusel oils for man may be ultimately decided. I believe that hygiene may now on good grounds take up the following position:—

1. It is certain that the higher alcohols, aldehydes, esters, &c., are not absolutely necessary for the flavour of draught-spirits. The thirty-three kinds of spirits free from fusel which were examined in Berlin had, *e.g.*, no unusual odours, or some of them were flavoured with the most varied aromas. Hence there is no necessity for a flavouring with fusel oil, or a minimum of this constituent might suffice. In Switzerland quantities of fusel oil not exceeding 0·2 (calculated for absolute alcohol) are permitted, which corresponds to 0·1 per cent., or less in the aqueous "schnaps." See *Chemiker Zeitung*, 1890, No. 81.

2. Even if the temptation to drink brandy were decreased by the elimination of the fusel oils, this would be decidedly no reason for their retention.

3. Fusel oil is far more poisonous than ethylic alcohol. It is, indeed, not probable that a proportion of fusel oil below 0·3 per cent. will render the action of ethylic alcohol more hurtful, but hygiene will rejoice over any legislative regulation of the question which demands a smaller proportion, say 0·1 per cent. But we must emphasise the conclusion that we have hitherto no warrant for regarding the fusels of one kind of spirit as less injurious than those of another, and

judge those of a pleasant flavour more leniently than such as have a disagreeable taste.

4. Though the removal of fusel oil is hygienically desirable, it represents only a subordinate point in the contest against alcoholism.

The other constituents of spirits have little importance. I cannot find a trace of sulphuric acid injurious to health. Constituents of impure water, copper, &c., must be judged according to § 201. Pyridine bases are poisonous, but in the proportions in which they may find their way into draught spirits by the addition of denaturised spirit, they are scarcely injurious. Nitro-benzol is a very powerful poison: twenty drops have proved sufficient for fatal poisoning, hence its addition must be absolutely condemned. It is questionable whether the very small quantities of hydrocyanic acid, which may be found in kirsch-wasser, &c., have any hygienic (toxicological) signification.

APPENDIX.—DECISION ON FINE SPIRITS AND LIQUEURS.

§ 413. There can be no doubt that if the points of view which have been developed above for draught-spirits are correct, they must be here also decisive. Only the fact that these liqueurs which are mostly very rich in alcohol, as much as 50 to 80 per cent. by volume (and often very rich in fusel oils), are consumed merely in small quantities and not habitually, can be adduced as a reason why hygiene has hitherto paid little attention to the meaning of these liquids. In fact, in deciding on these beverages the odour and taste of experienced connoisseurs play the chief part. Even a chemical examination throws very little light on the genuineness of a sample. In any case, quite special knowledge and materials for comparison are necessary.

The recent investigations of Nessler and Barth (*Zeit. f. Anal. Chemie*, 1895), and W. Fresenius (*ibid.* 1890), and especially of Sell (see Bibliography), have proved the abso-

lute incapacity of our present methods to recognise good imitations of cognac, arrack, and rum as falsifications.

Only one fine liqueur has experienced a fairly unanimous decision and condemnation, *i.e.*, absinth. It derives from wormwood (*Artemisia absynthium*) the poisonous ethereal oil of wormwood which aggravates the effects of alcohol to a very considerable extent, and produces muscular convulsions, klonic cramps, and epileptiform conditions in the type of chronic poisoning. The other vegetable ethereal oils (aniseed, fennel, &c.) are, according to Magnan, four or five times less injurious.[1]

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[1] The importation, sale, and consumption of this abominable liqueur seem to be increasing in Britain. Yet the "temperance party," who have now constituted themselves a political confederation, say not a word in protest.—*Editor.*

SECTION XVI.

CLOTHING.

A. Examination of Clothing.

§ 414. For a long time our clothing has been an object of diligent hygienic studies, which have been conducted with especial zeal for the last few years. All the physical properties of the different tissues have been carefully studied, partly with the aid of very delicate methods, so that their investigation in different respects has become very easy. But as few of these methods are practically applicable, and as they often require a peculiar apparatus for their execution, they will be in the sequel in many cases merely mentioned or quoted.[1]

The most important questions are the following:—

1. Examination of the raw material employed.
2. Examination of its behaviour with water and air.
3. Examination of its thermic properties.
4. Examination of colours and mordants with respect to their injurious influence upon health.

See section on Domestic Requisites (XVIII.).

1. The Distinction of the Textile Fibres.

I. From the Animal Kingdom.

§ 415. 1. *Wool*, from the sheep, rarely from other kindred animals (species of goat, camel, alpaca, and vicuna). The two last-mentioned llama-like animals of South America yield peculiarly fine wool.

[1] It has been inevitable that in many cases, instead of a full account of a method, there is given merely a brief notice of its results.

2. *Silk, i.e.*, cocoon threads of the silk-moth (*Bombyx mori*) and a series of other moths, especially the oak silk-moths (*Antherea yamamaya* and *Antherea Pernyi*), the Ailanthus-moth (*Attacus cynthia*), &c. A product of wild Indian cocoons has been introduced into trade as tussah-silk.

II. From the Vegetable Kingdom.

a. Hairs.

1. *Cotton, i.e.*, the seed-hairs of the cotton shrubs, various species of the genus Gossypium.

b. Bast Fibres.

1. *Linen*, from the flax-plant (*Linum usitatissimum*).
2. *Jute*, from the tropical shrub (*Corchorus capsularis*).
2. *Hemp*, from the hemp-plant (*Cannabis sativa*).

Numerous other vegetable fibres play a subordinate part, though rather as stuffing material than for spinning. See Von Höhnel.

§ 416. In the diagnosis of these fibres chemical methods play merely a subordinate part. If the material has been finely fibrillated (if necessary, by prolonged boiling in water, alcohol, or exceedingly dilute acids applied with caution), and freed as far as possible from colouring-matter, an observer of some experience[1] can generally, by a microscopic or micro-chemical examination, arrive at a certain decision in a few minutes. Fibres from the length and breadth of the tissue must always be examined separately, as the warp and the weft often consist of different materials. The tests and the reactions mentioned in the following explanations are:—

1. Ammoniacal solution of copper hydroxide, prepared by precipitating a solution of copper sulphate with a little

[1] The only difficulty is in the distinction between hemp and flax, which is hygienically unimportant. Intense dyes may render the diagnosis difficult.

ammonia, filtering off the cupric hydroxide in a funnel closed with glass wool,[1] and dissolving by pouring upon it a minimum of liquid ammonia. There is formed a deep blue liquid, which dissolves cellulose rather rapidly in the cold, but scarcely attacks lignified cellulose.

2. Aniline sulphate. A few drops of aniline oil are allowed to fall into dilute sulphuric acid, shaken up, and filtered if necessary. Lignified cellulose, if moistened with a few drops of this reagent, takes an intense yellow colour in a few minutes, whilst pure cellulose is not changed. The lignine reaction disappears on bleaching.

3. Molisch's reaction. A small specimen of the tissue, freed as much as possible from dyes by boiling in water, is covered with 2 *cc.* of concentrated sulphuric acid, and there are added two drops of a solution of thymol in water (saturated in the cold). If carbohydrates are present (especially cellulose, *i.e.*, vegetable fibre), the liquid takes a reddish-violet colour on agitation.

4. Reactions with iodine and sulphuric acid. Iodine solution = 1 *grm.* potassium iodide in 100 *cc.* of distilled water, to which so much iodine has been added that a little remains undissolved at the bottom. Sulphuric acid = 2 vols. glycerine + 1 vol. distilled water + 3 vols. concentrated sulphuric acid, which are added slowly, whilst the vessel is continually refrigerated.

The fibre is first treated with a little solution of iodine upon the port-object. The excess is removed, and from one to two drops of the sulphuric acid are added to the preparation, which is almost dry. Pure cellulose is coloured blue; lignified cellulose, yellow. Fibres which have been dyed and bleached give quite different reactions.

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[1] Or with asbestos.—*Editor.*

A. Conspectus of the Chemical Behaviour of the Materials of Clothing.

	Wool.	Silk.	Cotton.	Linen.	Hemp.	Jute.[1]
Boiling potassa-lye.	Sparingly soluble.	Easily soluble.	Not dissolved.	Not dissolved.	Not dissolved.	Not dissolved.
Copper oxide ammonia.	Swells slowly.	Not affected.	Easily soluble, with tumifaction.	Tumified but not dissolved.	Tumified but not dissolved.	Tumified but not dissolved.
Aniline sulphate.	No change.	No change.	No change.	No change or a pale yellow.	Deep yellow.	Deep yellow.
Molisch's reaction.	Absent.	Absent.	Purple-violet.	Purple-violet.	Purple-violet.	Purple-violet.
Cold concentrated sulphuric acid.	Slowly soluble.	Quickly soluble.	Quickly soluble.	Quickly soluble.	Quickly soluble.	Quickly soluble.

Cold concentrated hydrochloric acid dissolves only genuine silk, but not tussah-silk and the other fibres.

Fig. 119.—Genuine Silk.[2]

a and *b*, single threads; *c*, two threads connected by the sheath of sericine.

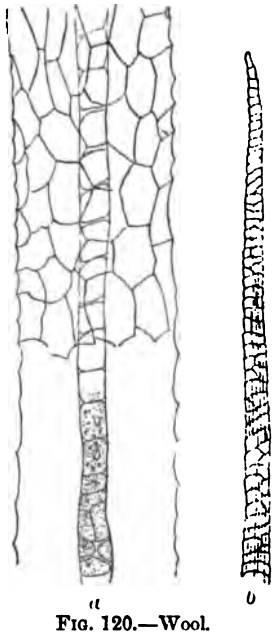

Fig. 120.—Wool.

a, coarse bristly hair with a strong layer of pith; *b*, hair of wool without pith.

[1] On the detection of jute see *Zeit. f. Analyt. Chemie*, 1890, p. 133.

[2] Silk of *Bombyx mori*. The term "genuine silk" is scarcely admissible. —*Editor.*

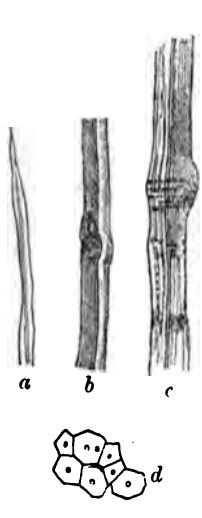

FIG. 121.—Linen.

a, extremity of fibre; *b*, *c*, manufactured linen fibres with knotty places; *d*, transverse section of the unchanged fibre.

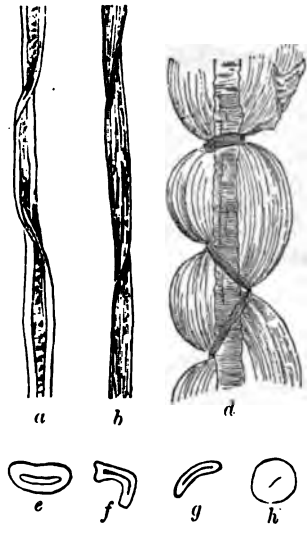

FIG. 122.—Cotton.

a, *b*, fibres with rough cuticle and twistings; *d*, action of ammoniacal cupric oxide; *e*, *f*, *g*, *h*, section showing the slit-like lumen.

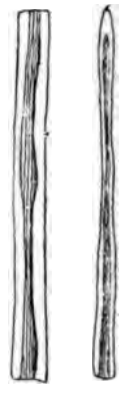

FIG. 123.—Jute.

The channel (lumen), of variable width, is distinctly visible.

CONSPECTUS OF THE MICROSCOPIC

	Wool.	Silk.	Wild Silk.
Section and Diameter.	Roundish. Finest sorts, 12 to 37 μ; coarsest, 80 to 100 μ in diameter.	Round. 8 to 24, and in mean 15 μ in diameter.	Oval.
Channel (lumen).	No true lumen; central pith-cells sometimes filled with air.	Wanting.	Wanting.
Extremity of fibre.	Pointed.	Torn off.	Torn off.
Surface and internal structure.	Surface rough from external characteristic epidermic scales, extending sometimes in length and sometimes in breadth. Beneath the epidermic layer there lies a longitudinal layer of parallel fibres. Cubic cells are contained in the centre of the coarser hairs, those especially of a bristly character. The soft, thin, pithless wool-hairs, and the stout, shining bristly hairs containing pith are therefore very distinct in structure; they occur in the various wools, partly mixed and partly separated.	In raw (not ungummed silk) there are always two threads of fibroine inclosed in a delicate sheath of sericine; the latter is traversed by transverse folds, breaks, and chinks. The surface of the real thread is quite smooth. The interval between the two threads imbedded in the sericine may, on superficial examination, simulate a channel in a thick thread. In wrought silk the double threads are always resolved into single threads.	Like true silk; but in the great majority of the wild silks the surface displays a delicate longitudinal striation.

BEHAVIOUR OF CLOTHING MATERIAL.

Cotton.	Linen.	Hemp.	Jute.
Kidney-shaped, pressed flat. 12 to 42 μ, but mostly 15 to 25 μ thick.	Raw, polygonal, angular; manufactured roundish with blunt angles; 12 to 24 μ, but mostly 15 to 17 μ in diameter.	Similar.	Roundish, polygonal; 20 to 25 μ.
Broad in coarser kinds; a very narrow slit in finer sorts. The former have a flattish section but the latter a roundish section.	Point formed on section; often hard to see.	Slit; often ramified; narrow at extremities.	Varies at different points of fibre. Mostly very wide at the extremities.
Blunt.	Very pointed.	Blunt; often with 2 or 3 collateral points.	Blunt.
Surface of thread rarely smooth, generally finely granulated or striated, in consequence of the rough cuticular layer. The threads are characteristically twisted around their longitudinal axis, the coarser, thin-sided sorts with wide channels most strongly. The behaviour of the fibre with ammoniacal copper oxide is very characteristic. The cuticle and the inner lining of the lumen resist solution; the latter contracts in folds, the former forms solid rings, between which the swollen cellulose forms bulging protrusions (Fig. 122).	When raw, but still more when manufactured, the fibre shows numerous very characteristic longitudinal fissures and chinks. The transverse kinks and breaks are also very characteristic.	Very similar. Certainly distinguished from flax only by searching for other constituents of the tissues, epidermis, hairs, tubes of colouring-matters, &c. See Bibliography. Used nearly exclusively for sacks and cordages, scarcely for sheets and coarse shirtings.	Similar, but easy to distinguish by the wide, unequal lumen Macroscopically characterised by the lustre and the coarseness of the fibres. Used almost exclusively for curtains, cheap furniture tissues, quilts, and sacks.

2. Behaviour of Clothing with Air and Water.

1. BEHAVIOUR WITH AIR.

§ 417. For scientific purposes we proceed as in testing the permeability of building materials, according to Von Pettenkofer. A tube of 1 *scm.* in section, or preferably wider, is stretched over the tissue, and the air which passes through at a certain pressure (5 *cm.* of water as measured.) Everything depends on the degree of tension of the tissue, its being stretched smoothly, &c. For practical purposes a consideration of the material is generally sufficient, remembering the following relative figures determined by Von Pettenkofer at a water-pressure of 4·5 *cm.*

There passed through	flannel . .	100	parts.
„ „	medium fine linen	58	„
„ „	silk . . .	40	„
„ „	buckskin . .	58	„
„ „	kid-leather . .	1	„
„ „	wash-leather .	51	„

Nocht obtained much more considerable differences when he worked with a difference of water-pressure of only 0·04 water and pieces of tissue of 56·7 *scm.* :—

Flannel . . .	100	Old fustian . .	98
Old flannel . .	128	Linen . . .	16
Jäger's cloth . .	150	Lahmann's cloth .	249
Fustian . . .	25		

Nocht has further tested the permeability of wet tissues for air by the same method at pressures of 1 to 2 *mm.* The result was that if we take the permeability of dry flannel = 100, that of Lahmann's material (wet) was 28, Jäger's material 3·6, and the other tissues of wool, cotton, and linen about 2.

2. BEHAVIOUR WITH WATERY VAPOUR.

§ 418. A determination of the combining power of aeriform water is of subordinate interest. For all clothing material it is independent of the temperature, and depends merely on the relative moisture and the material. The determination is effected by accurately weighing specimens of cloth, previously dried over sulphuric acid, in air-tight tin cases, exposing

them then to air of known moisture, and determining the increase of weight in ½, 1, 2, and in 48 hours. In fog liquid water is suspended in the air, and the absorption of water rises very decidedly above the hygroscopic maximum.

1000 *grm.* of dry cotton and linen absorb in two hours in air saturated with moisture about 80 *grm.*, flannel absorbs 118 *grm.* of watery vapour. The colour has no influence. (Boubnoff, *Arch. f. Hyg.*, i.) According to Nocht, cotton absorbs in forty-eight hours from 164 to 174 *grm.*, linen 206 *grm.*, and flannel 281 *grm.*

3. BEHAVIOUR WITH LIQUID WATER.

§ 419. (*a.*) For determining the absolute capacity for water we plunge the air-dried tissues to be compared under water in a dish, and press them several times together. Lastly, we submit all the substances in question to pressure with the hand as equal as possible, and determine the increase of weight, which may be calculated for 100 *scm.* or 100 *grm.* Of course we obtain in this manner only comparative values, which indeed are somewhat fluctuating, as considerably more water remains in the elastic wool. In 100 *grm.* there were found—

	Flannel.	Cotton.	Linen.
Von Pettenkofer . .	91·3	...	74
Linroth	148	82	81
Boubnoff . . .	108	68	75
Nocht	183	162	126
	258	218	...
	(Jäger's tissue)	(Lahmann's tissue)	

The first three samples were strongly pressed with the hand. The last samples were not pressed, but merely hung up to drain until water ceased to drop.

(*b.*) The power of taking up water, *i.e.*, the rapidity with which it absorbs water, is ascertained. (Compare Mense, C., *Ueber das Verhalten von Kleidungsstoffen gegenüber tropfbar-flüssigem Wasser.* Dissertation, Munich, 1890.)

1. By laying upon a capsule of water, and observing when it sinks. Warm water wets tissues much more rapidly than does cold.

2. By stretching the cloth on a frame, allowing drops of water of a known size to fall upon it (*e.g.*, $\frac{1}{10}$ to $\frac{5}{10}$ *cc.*).

3. By weighting slips of cloth by sewing a glass rod to their lower end and suspending them to the depth of 1 *cm.* in water (the level of which is kept constant), and observing the height and the speed of the rise of the moistened zone.

Such experiments should always be made simultaneously with various specimens, remarking that wool (especially Jäger's wool) was wetted most slowly,[1] then followed cotton and linen, while silk was wetted most rapidly.

Tissues of the same material are wetted the less readily the heavier the dressing and the rougher the surface. Washing increases the absorbent power of most materials, but in silk, which is rendered rougher, the contrary effect is produced. A decided influence of the greater or less density of a tissue was remarkably not to be recognised.

The following may serve as examples:—

Complete moistening, *i.e.*, sinking of tissues floating upon water, took place, according to Mense:

	Cold Water.		Hot Water.	
	Unwashed.	Washed.	Unwashed.	Washed.
Silk . .	at once	5 seconds	at once	at once
Linen . .	1 minute	6 seconds	3 seconds	at once
Cotton . .	252 minutes	4 minutes	5 minutes	5 seconds
Flannel .	not at all	96 minutes	25 minutes	13 minutes
Jäger's wool .	not at all	not at all	28 minutes	21 minutes

If it is required to test tissues rendered water-proof by impregnation with certain salts (especially salts of aluminium) we proceed in a similar manner, adding, however, an examination of the permeability for air, in order to ascertain whether it has been affected in this respect by the process of impregnation.

Experiments on tissues which have been worn and washed are desirable to ascertain the durability of the water-proofing.

[1] Nocht found that ordinary flannel was wetted much less readily than Jäger's wool. Lahmann's "reform cotton" behaved like Jäger's wool. Half wool flannels were wetted with as much difficulty as pure wool. Old, worn woollen tissues were wetted very rapidly, perhaps because the epidermal coating of the wool-fibre was injured. I found that extraction with ether had no influence on the capability of the wool for absorbing water.

(*c.*) Testing the behaviour of the clothing with sweat. According to the researches of E. Cramer (*Arch. f. Hygiene*, x.), a standard for the quantity of sweat absorbed may be found by determining the quantity of sodium chloride in the clothing. Sweat contains 0·38 per cent. sodium chloride; the clothes are extracted by repeated applications of hot water, using a meat-press and titrating the chlorine in the collected and concentrated extracts. Cotton worn next to the skin retains the solid constituents of sweat much better than does wool, which allows them to travel into the outer layers of clothing. If a woollen shirt remains clean longer, the outer garments, if of woollen, are soiled the more. The soiling by sweat (as measured by the sodium chloride) on drawers, shirt, and socks (all of cotton) is in equal times as 1 : 2 : 8.

(*d.*) The elimination of the water taken up (drying) may be approximately determined by hanging up the tissues and weighing them at certain intervals. The behaviour of the hygroscopic water has no practical interest; the escape of liquid water takes place much more slowly and uniformly from wool than it does from cotton and linen.

In an instance given by Boubnoff wool evaporated, *e.g.*, in the first seven half hours, from 9·8 to 14·6 per cent. each, in all 87·1 per cent. of water; in the following half hours respectively 6·5, 4·5, and 1·9 per cent. Cotton and linen give off about 50 per cent. in the first half hour, in the second 30 per cent., and in the last half hour the remainder. In that time wool loses only about 36 per cent. According to Nocht, however, thick cotton tissues (fustian, Lahmann's tissue, &c.), behave like wool on drying, though he found thin linens dry more rapidly.

3. Thermic Properties of Clothing.

§ 420. The qualities of clothing materials in reference to the conduction and radiation of heat concern us merely in as far as they affect the thermic economy of the body.

The radiation of heat from the rough surfaces of clothing is greater than from the smooth skin (Rubner), and it is approximately equal for all kinds of tissues (Krieger). They may be ascertained (Rubner) by observing a thermo-battery

3. By weighting slips of cloth by sewing a glass rod to their lower end and suspending them to the depth of 1 *cm.* in water (the level of which is kept constant), and observing the height and the speed of the rise of the moistened zone.

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a sparingly mobile stratum of air forming an exceedingly bad conductor of heat.

To test the retardation of the conduction of heat[1] Krieger (*Zeit. f. Biol.*, 1869) enveloped a sheet-metal cylinder filled with hot water successively in the substances to be tested, and observed the falling of a thermometer introduced. These experiments have been improved and extended, in a manner which may serve as a model, by Schuster (*Arch. f. Hygiene*, viii.). The latter observed by how many degrees centigrade the cylinder cooled in forty minutes, when at the beginning of the experiment it was 33° warmer than its surroundings. In this method the loss of heat was reduced by thin linen tissue about 4°, and of thick woollen cloth by 18° to 27°. A second layer, supported at some distance from the clothed cylinder by means of a fine wire framework, reduced the loss further by about 20°.

As the experiments showed that all clothing materials (perhaps with the exception of silk) are equally good or bad conductors of heat, but that their bad conductive power depends chiefly on the circumstance that much finely-divided, sparingly mobile air is inclosed in the loose tissue, an examination of the texture of the material, and of its thickness, renders it possible to decide on its power of retaining heat, even without experiments. Wool, in addition to its loose texture, is further rendered retentive of heat by the circumstance that its rough surface irritates the skin, and causes a determination of blood thither, and that its prominent hairs retain a moderately thick stratum of heat between the skin and the woollen shirt.

Loss of Heat.—The diminution of the total loss of heat in man by means of clothing has been shown by Rubner by his air-calorimeter (*Zeit. f. Biologie*, 1888), which depends mainly upon the principle of measuring the heat communicated to an enclosed volume of air by a human arm, its expansion being ascertained by a volumeter. A minute description of

[1] These experiments determine jointly the indirect and direct effect of the disturbed conduction of heat.

this apparatus, which is scarcely available in practice, cannot be given here. Suffice it to say that the apparatus, if carefully calibrated, is applicable for the accurate measurement of the calories given off. Two similar apparatus allow of a simultaneous comparative examination of both arms, the one clothed and the other not clothed.

4. Permeability for Rays of the Sun.

§ 421. Boubnoff has recently examined to what extent tissues transmit the sun's rays by observing the blackening of salts of silver covered by different tissues. He observed that all substances transmit the rays of the sun, those undyed much more than those dyed, black materials least. The permeability for air has no effect on that for the rays of the sun, though the thickness of the material is of importance.

APPENDIX.—THERMIC PROPERTIES OF WET TISSUES.

§ 422. The above-described methods render it possible to examine the effects of wet tissues upon our thermic economy. Our feelings tell us that the efficacy of clothes as a protection for heat is cancelled by thorough wetting, and even over-balanced. Rubner found that an arm wrapt in moist flannel bandages loses by conduction and radiation as much heat as if completely naked, and that the total loss of heat, including that due to evaporation, was three times that of a naked arm, and five times that of one clothed.

Although no figures are available, it may be assumed with certainty that cotton and linen tissues which are rapidly saturated by rain or sweat, and which when wet rapidly and totally lose their porosity, will behave more unfavourably than wool in experiments of measurement. At least Nocht found that a cylinder of hot water wrapped in wet cotton and linen tissues was cooled more strongly by about 33 per cent. than if it was wrapped in wool or mixed wool. Here Lahmann's cotton did not behave differently from other vegetable fibres.

5. Bacteriological Examination.

The investigation as to the microbia present in clothing materials must be effected after the careful comminution of a weighed and measured sample of the tissue exactly according to the methods for the bacteriological analysis of soils. In order to ascertain the property of clothing, especially underclothing, to take up bacteria on wearing, Hobein (*Zeit. f. Hygiene*, ix.) proceeded by fastening to the inside of underclothing, close to each other, pieces of different materials in immediate contact with the skin, each of the size of one square centimetre. As was to be expected, the property of taking up microbia depended directly on the roughness and the thickness (loose texture) of the material. For particulars see the original.

The facts recently ascertained that pathogenic organisms are separated out with sweat (Brunner, *Berlin klin. Wochenschrift*, 1891, No. 21, and Von Eiselberg, *ibidem*, No. 23) must be kept in mind. Pathogenic organisms are more frequently introduced into clothing by pus, fæces, gonorrhœal secretions, sputa, &c. An examination for particular kinds would have to be effected by staining, cultures, and inoculation in the known manner.

The examination of rags is effected in the same manner.

B. Decision on Clothing.

§ 423. With the decision upon clothing, as regards its durability, fastness of dyes, value in comparison with price, &c., however important in practical life, we have here nothing to do, since the quality of the raw material and the method of production have in many cases a decisive influence, which can only be estimated by the technicist.

For the recognition of artificial wool, rag-wool (shoddy, mungo) in woollen goods, I must refer to the work of Von Hoehnel.

I will here merely make a few remarks on the appropriate

selection of clothing, especially underclothing, for different climates. It must not be forgotten that some individuals are much more sensitive than others to unsuitable clothing, and that habit exerts an incredible influence.

1. Clothing for Cold Climates.

§ 424. Thick materials woven loosely with many fine intervals in which the air is not easily movable, therefore by preference wool. Many strata one above the other are to be recommended. Furs with the hairy side turned to the skin afford an especially energetic protection against cold. The garments should fit rather tightly.

If wool cannot be tolerated next to the skin on account of its great sensitiveness, soft vicuna wool affords a less irritating substitute. As long as the wearer does not sweat, cotton cloth of a porous texture (reform-cotton, &c.) may do good service.

2. Clothing for Hot, Dry Climates.

§ 325. Thin cotton or linen tissues. The garments should be roomy and consist of but few layers. For wear in the open air light-coloured garments should be used to diminish the absorption of heat, but with dark linings to cut off the excessive action of the sun's rays.

3. Clothing for Hot, Moist Climates.

§ 426. Light woollen tissues which take up sweat slowly, but which even when thoroughly moistened are not such good conductors of heat as linen and cotton, since numerous pores still remain filled with air. If there are no considerable fluctuations of temperature, porous cotton tissues, Lahmann's material, &c., may be worn.

4. Clothing for Climates with Fluctuating Temperature.

§ 427. As proposed under 3, but the substitution of cotton for woollen tissues cannot be recommended. In addition, overcoats which may be put on or thrown off as required.

5. Clothing as Protection against Rain.

§ 428. Caoutchouc for garments must be almost absolutely condemned. It is admissible only in a cold, wet climate, as the body underneath quickly breaks out into sweat. Porous, water-proof, impregnated woollen tissues have probably a great future. Even ordinary woollens, as compared with cotton, afford for a long time protection against rain; but, finally, woollen garments become very heavy from the large quantity of water which they take up. On this account soldiers' cloaks have to be carried rolled up in rain and used as a dry nightdress.

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SECTION XVII.

SOME HINTS FOR THE HYGIENIC EXAMINATION OF AND DECISION UPON A DWELLING-HOUSE AND ITS ARRANGEMENT.[1]

I. Building Materials.

§ 429. The most important building materials in use are, along with quarry stones, hewn stones, and artificial stones (bricks, slag bricks, so-called floating bricks, cement castings, &c.), wood and iron. The connecting materials used are mortars of lime, gypsum, and cement in the widest sense of the word.

1. The Stones.

An examination of building materials is scarcely demanded from the hygienist; the experience of the architect generally suffices to make a suitable selection. Human skill is able to make even less suitable material fit for use by appropriate application. For instance, quarry stones impervious to air can be utilised by means of thick connective masses of mortar, and by the large dimensions or by the good artificial ventilation of the rooms constructed.

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[1] The following section shows by its title that I confine myself as far as possible to the most weighty and most elementary questions in this region which has hitherto been so little explored hygienically. I have contented myself with simply indicating many points, and I have made little mention of the use of complicated and sparingly available apparatus. A division into "examination" and "decision" is mostly proposed where no especial methods of investigation were to be described. Some information concerning the locality and the soil for building are to be found in § 165. In various places I quote as projects for imperial legislation the moderate minimum requirements which the "German Association for the Care of Public Health" formulated in 1889 at its meeting in Strassburg as "Draught of Imperial Regulation for Insuring Healthy Dwellings," and has published in its report after the most thorough discussion by the most experienced authorities.

For special purposes we may occasionally determine:—

1. *The volume of the pores* (§ 161).

2. *The permeability for air.* A circumstantial experiment. We ascertain how much air passes through cylinders of different building materials of equal surface (*e.g.*, 1 *sdm.*) and equal thickness (*e.g.*, 1 *dm.*) under equal pressures. The experiments presuppose that the curved surface of the cylinder is made perfectly air-tight by a coat of water-glass, paraffine, or caoutchouc. Any accidental crevice, crack, &c., renders the block useless.

3. *The quantity of water which the stone can take up from moist air and from liquid water.* The absorption from moist air is trifling, but from water, finely porous stones, *e.g.*, bricks, gradually take up water almost to the extent of 100 per cent. of the volume of the pores. Low porosity is always a sign of low permeability for air.

4. *The rapidity with which water is taken up.* The narrower the pores the slower is the absorption, but the more completely they are filled.

5. *The resistance of the stones and of the hardened mortar to strain and crushing.* For this purpose very costly testing machines are required. The examination generally takes place in official establishments, which issue certificates to manufacturers and dealers.[1]

6. *The resistance to frost.* If stones after saturation with water are alternately frozen (in a space cooled by means of a freezing mixture) and thawed again, they crack, if of inferior quality, and fragments, small or large, split off and crumble away. The method is to be left to the technologists.

7. For bricks, especially if they have to serve for the construction of arches, &c., it is necessary to ascertain that they are not made from clay containing limestones. Such stones when the bricks are burnt become caustic lime, and when moistened they cause a disruption of the bricks, as the quicklime is converted into calcium hydroxide with an increase of volume. As a test a considerable number of bricks are steeped in water for an hour, placed in a shaded place, and examined after the lapse of twenty-four hours. Such as contain lime are burst. White crumbs of lime are often seen on the surface of bricks.

[1] It is very questionable how this subject can come under the purview of the hygienist at all. It is the business of the architect.—*Editor.*

2. Timber.

§ 430. Timber may be examined for its—

a. Dryness.—Recent timber contains from 30 to 60 per cent. of water; air-dried, fit for building, from 20 to 25 per cent.; a lower proportion than 15 per cent. is rarely found in perfectly air-dried wood.

b. Firmness.—No cracks must occur in the direction of the annual rings, but longitudinal chinks may be found. The exact examination takes place in the same manner as for stone.

c. Soundness.—Colour, gravity (not too light), resistance to pressure and shocks, absence of *Merulius lacrymans* and other fungi producing diseases in timber. (See § 439).

d. Botanical origin.—Men of experience very readily distinguish most kinds of timber macroscopically, and a microscopic diagnosis is possible even with small fragments. (See Möller's copiously illustrated article, "Nutzhölzer," in *Dammer's Lexicon*).

Oak-wood is highly valued on account of its firmness, endurance of weather, extreme resistance to water, and relatively great security against fire. Resinous fir and larch-wood are highly prized on account of their great resistance to the effects of weather and moisture. Larch grown on mountains resists alternate moisture and dryness longer than oak, and is therefore preferably used for structures which lie partly above and partly below or close to the ground. The common pine, however, finds more general application on account of its low price. All mountain timber is preferred to that of the plains. The pitch-pine is not used in Germany for ordinary buildings. The red beech serves chiefly for floors (passages, &c.) and balustrades of stairs, and when impregnated for superior flooring. Ash is suitable for many purposes as a substitute for oak.

e. Season of Felling.—Timber felled in winter is often considered the most valuable. If the transverse section is touched with iodised potassium iodide it shows a blue colour from the starch deposited in the medullary radiations. According to R. Hartig the preference for winter wood is unfounded.

f. Preservative Agents.—The examination whether wood

has been artificially dried, steamed (with or without pressure), lixiviated (*e.g.*, floated), does not concern us. On the other hand, the detection of metallic salts which have been used for impregnation has an interest. Burnetising ($ZnSO_4$), Boucherising ($CuSO_4$), and Kyanising ($HgCl_2$) meet with extensive application. In general we proceed according to § 460. Zinc and copper are found in the ash, and may be at once determined. Mercury may be sought for after destroying the wood with chlorine, according to Fresenius and Babo. Such impregnated timber must not be used as fuel for bakers, and kyanised wood should not even be employed for dwelling-houses and stalls for cattle.

An impregnation of wood with the heavy oils of tar (Bethelising) betrays itself by its odour and inflammability. The preservative action of this process is especially powerful.

On iron structures little can be said from a hygienic point of view.

Within buildings they require a fire-proof coating by means of pieces of brick, Monier-constructions, &c., as in serious conflagrations they may occasion or accelerate the collapse of the buildings. If properly enclosed they may be considered fire-proof, and gradually displace the use of wood in buildings, thus diminishing its dangers (wood diseases and fire).[1]

3. The Cements (Mortars).

§ 431. For connecting the building materials there are used various sorts of mortar, which will be first briefly described and then represented in their applications. We distinguish wall-mortar, which serves to connect the stones, and plasterers' mortar, with which they are coated over.

1. *Lime Mortar.*—A mixture of one part stiff lime-paste (slacked lime is slowly worked up with water to a stiff

[1] The most important question concerning timber is whether it is *fresh*. The timber of old houses, condemned as hopelessly unhealthy and pulled down, is bought up, planed over, and used in the construction of new houses, where it may introduce zymotic diseases.—*Editor.*

uniform paste) and from three to four parts of calcareous or quartz-sand[1] of very various fineness.

Mortar hardens in the air by loss of water and slow absorption of carbonic acid.[2]

The investigator seeks to ascertain:

1. *Proportion of Free Water* (K. B. Lehmann and Nussbaum).—The authors weigh a copper boat (Fig. 124, *A*) in a weighing-tube with caoutchouc stoppers, fill the boat with the mortar in question, and weigh it again in the weighing-tube. It is preferable to undertake simultaneously a number of

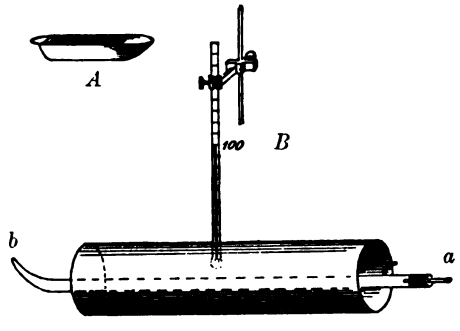

FIG. 124.—Apparatus for the Analysis of Mortar.

determinations of different samples of mortar. The boats are thrust one behind another into a combustion-tube of sparingly fusible glass (Fig. 124, *B*), drawn out at one end to a beak. Two small gas-flames are then lighted beneath the metal cylinder, and the thermometer is observed. It can be easily kept at from 100° to 105°. There is drawn through the combustion-tube for ½ to 1¼ hour a current of air by means of an aspirator which is joined on at *a*. The air before entering at *b* passes first through a Peligot-tube of the

[1] Even if the mortar contains, as, *e.g.*, at Munich, gravel (about 50 per cent.), it is not sifted prior to analysis.

[2] Much mortar used in London and some other large English cities is made, instead of clean sharp sand, with sifted soil from fields and gardens, rich in decaying organic matter. The lime is slacked in large quantities, and is allowed to lie for a considerable time before it is used. It is needless to say that such mortar is not merely deficient in adhesive power, but gives off unpleasant and hurtful fumes.—*Editor.*

strongest soda-lye, then a tall vessel filled with soda-pumice, a Peligot-tube with sulphuric acid, and a tall vessel with sulphuric pumice (see § 128). All the carbonic acid and the water are thus removed, and the mortar is dried without any possible absorption of CO_2.

2. The proportion of calcium hydroxide ($Ca(OH)_2$). It is best to heat 100 *cc.* of distilled water for a few minutes to gentle ebullition in a flask of the capacity of 120 *cc.*, in order to expel the carbonic acid. Portions of mortar rapidly weighed (of recent mortar about 1 *grm.*, and of old mortar from 3 to 8 *grm.*) are dropped in, and the flask is closed with a caoutchouc stopper. After from 24 to 48 hours, during which time the cold contents of the flask are frequently shaken up, twice 25 *cc.* of the clear supernatant liquid are taken off from the undissolved matter and titrated with decinormal sulphuric acid after an addition of rosolic acid. Each cubic centimetre corresponds to 3·69 *mgrm.* $Ca(OH)_2$. As 100 *cc.* of water dissolve 1 *mgrn.* $CaCO_3$, we find, strictly speaking, always 2·6 *mgrm.* $Ca(OH)_2$ too much. All other methods we find much less practical.

2. *Cement Mortar.*—By cement we understand an artificial preparation which, in the kind most frequently met with, Portland cement,[1] is obtained by burning a mixture of natural aluminium silicates with limestone. The masses are well mixed, made up into bricks, and burnt to a sintering state (*i.e.*, incipient fusion). The finished product contains about 60 per cent. CaO, 24 per cent. SiO_2, 7·5 per cent. Al_2O_3, 3·5 per cent. Fe_2O_3, and small quantities of potassa, soda, and magnesia.

On burning there are produced from aluminium silicate, iron silicate, and calcium carbonate, fusible calcium ferrate; there are unstable compounds of lime with silica and alumina suspended in the melt (calcium silicates and aluminates not accurately known), whilst water and CO_2 are eliminated. If the elevated temperature is maintained too long, and there are formed solid crystalline compounds of the kind intimated, the cement loses its cohesive power.

If properly burnt Portland cement comes in contact with water, there are formed calcium-hydrosilicate ($CaSiO_3 + H_2O$), calcium hydro-aluminate, and ferrate. Calcium hydroxide is set free, which

[1] I cannot here enter into the analyses of cement, the consideration of Roman cement (a kind less strongly burnt, poorer in lime, setting quickly, and chiefly suited for hydraulic work) and puzzolane cement (a mixture of ground rocks, such as puzzolane, trass, &c., containing silica and alumina, &c., ground up with caustic lime). On this subject, which as yet is not perfectly chemically intelligible, mere indications must suffice.

gradually takes up CO_2, and thus contributes to the solidity of the cement. The calcium hydroxide not combined to carbonate crystallises by the influence of the alkalies.

Cement remains perfectly compact and impervious only whilst moist (preferably under water); in the air there always occurs a certain shrinking (minute chinks, and sometimes the separation of entire surfaces of cement from the stones). Of the various causes of this phenomenon I mention only that the silica which was at first swollen afterwards shrinks again. A high proportion of magnesia (above 3½ per cent.) especially deteriorates the cement. (See *Chemiker Zeitung*, xv. 1891, p. 1145).

The several kinds of cement behave very differently as to the time which they require for hardening (if it takes longer than two hours the cement is said to set slowly), as to the proportion of sand which may be added without injuring the firmness of the concrete to be formed, &c.

We may easily ascertain the time of setting or hardening by mixing up small lots of cement with water. Complete hardening does not take place until the lapse of some days, or with many cements even weeks. The trial lots must be kept moist in the meantime, and a trial with hammer and chisel enables us to form some decision as to the firmness obtained. All cement factories, moreover, cause their products to be officially tested,[1] and send out along with their products certificates of their cohesive power, firmness, and time of setting.

For structures above the level of the water or the ground cements which set slowly are preferred; those which set quickly have often lost their cohesive power before they come to rest in their places. In this case they have no more firmness.

Cement is of great importance in modern elevated constructions for the preparation of concrete (a mixture of river-gravel, fragments of stone or brick, and cement). Wall-gypsum is also fit for use above ground. Such mixtures serve very extensively for producing firm foundations, bedding for pavements, and massive intermediate flooring. In a hygienic point of view the last employment is important; it presents great advantages for cellar stories, upper and basement kitchens, sculleries, baths, and closets,

[1] This refers, of course, to Germany.—*Editor*.

as compared with floorings on wooden beams, which in such positions are very objectionable. It has an advantage over arches, as affording a horizontal floor without demanding great height.

3. *Mixed Mortars of Quicklime, Cement, and Gypsum.*— For improving lime-mortar, that is, for amending, hardening, and for making it more quickly cohesive, so as to expedite work, additions of cement or gypsum are often used.

For this purpose only cements which set slowly can be employed, as others already lose their cohesive power before the mortar is used, and then they injure instead of improving the firmness of the mass. But the behaviour of the different cements is dissimilar, and an experiment is required before they are used.

Besides the frequent addition of gypsum as plaster for inside walls, it is also used in many places (*e.g.*, the Southern Harz) for plastering outer walls. This mass, known as "wall-gypsum," sets more slowly than modellers' gypsum; it is weather-proof and attains great firmness, both which points are proved by buildings erected in the middle ages. This gypsum has a coarser grain than modellers' gypsum; it is burnt differently, up to a red heat, and does not expand on setting (see Feichtinger.)

II. Plan of the Building.

§ 432. In drawing up the sketch of ground-plan it is in the first place important to carry out the programme of the owner at the least expenditure, and further to utilise the plot of ground at disposal in the most advantageous manner, effecting a distribution and arrangement of the rooms suitable in every respect.

The hygienic demands on the plans for building are not yet universally recognised, and are not, indeed, sufficiently established to expect full recognition. The most important of these requirements are:

1. The staircase, the kitchen, and offices should be placed at the shady sides, if any (or at the least favourable side of the plot as regards air, light, and insolation), so that the sunny or more favourable aspects may be fully and entirely reserved for the rooms which serve for prolonged occupation.

2. The rooms in which malodorous gases and vapours are produced (kitchen, wash-house, bath, and closet) should not be in the direction exposed to the local winds, as otherwise the air from them will be conveyed through the dwelling- and sleeping-rooms.

3. For summer ventilation it is necessary to arrange the rooms so as to provide them with window and door openings in such a manner that a through current may be producible in all rooms, as otherwise on calm sultry days a sufficient aëration is not attainable. This condition is of great value for cooling the rooms in the evening.

4. All rooms intended for prolonged occupation must have their windows on the sides which receive sufficient light, air, and sun.

5. All other rooms (ante-chambers, hall, bath, W.C.) should at least be sufficiently supplied with indirect light, and thorough ventilation for them must be secured.

By a proper arrangement of the staircase a tolerable illumination and sufficient ventilation may be provided for the ante-chambers, if these have no window leading into the open air. In every such room there is placed a window (with an iron grating against burglars) opening to the staircase, whilst the latter has, near its ceiling, ventilating apertures which can be easily regulated with a chain and catch (lattice-traps, tilting-boards, &c.).

6. The number and position of the staircases must be such that in danger of fire they can be quickly and easily reached from all parts of the house. For further security it is necessary that the ante-chamber, hall, house, and court doors must open outwards, and that every dwelling-room has a direct exit to the hall or the staircase.

The proposed Imperial law makes the extremely moderate demands that—

The height of a building towards the street must not be greater than the distance to the opposite line of buildings.

1. The greatest permissible height of the walls of the building facing the court, and provided with the windows prescribed in § 7, is $1\frac{1}{2}$ time the mean distance from the opposite boundary of the vacant space.

2. The mean width of a court upon which windows open must not be less than 4 *m.*

3. A joining together of adjacent plots of land in order to obtain the prescribed distance, or the prescribed minimum width, is permissible as long as it is guaranteed that the courts shall not be built upon.

4. Every part of a ground-plot which is not built upon must be provided with an access for the sake of cleansing at least 1 *m.* in width and 2 *m.* in height.

5. On building lots which are already occupied with loftier or more crowded buildings than the stipulations of § 2 admit, the following regulations come into force in case of new structures:

The height of a building to the street may be $1\frac{1}{2}$ time the distance to the opposite line of buildings, and towards the court three times the width of the court.

The width of the court may be reduced to 2·50 *m.*

6. In applying this determination no deterioration of the conditions of light and air formerly existing must be in any case occasioned.

A new structure is permissible only if care is taken for the sufficient supply of wholesome drinking-water, and for the removal of refuse and waste matter in a manner not injurious to health.

III. Examination of and Decision on a House when completed.

I. Stability and Durability.

§ 433. 1. Thickness of the walls. Walls built solid, if loaded, must be at least from 25 to 30 *cm.* in thickness. If such walls are higher than 10 *m.*, they must up to that height be thicker by at least 12 to 15 *cm.*

All loaded walls must be connected together in each story by means of beams or of iron bearers, so that no bulging outwardly may occur; this is especially to be kept in mind where the thrust of an arch or any similar action may come into play. The stability of a wall depends indeed as much on the firmness of the materials employed (stones and mortar), and the goodness of the workmanship, as on its thickness. All the joinings must be perpendicular or horizontal, and be everywhere of equal width, if bricks are used.

2. Defects in consequence of bad workmanship or of insufficient thickness show themselves by fissures and cracks. If they are short and very narrow no danger is to be appre-

hended; but if they extend through entire stories or through several stories, or if they are wide (4 *mm.* and upwards), a thorough investigation by experts is required, or a repair or rebuilding of the parts endangered. If such defects appear before the completion of the structure, it must be considered that the loading will be very considerably increased with use.

3. If the building-ground or the foundations were bad, or if the intermediate floors were not strong enough, or if in inhabited houses they have been weakened by timber diseases, this is shown by subsidence. This defect is perceived partly by chinks and crevices, partly by the settling of parts which are heavily burdened (such as near stoves, hearths, safes), but especially by the circumstance that the locks of doors no longer fit, doors and windows gape or become wedged up, or the floors no longer lie horizontally.

2. Cellars and Cellar-Dwellings.

§ 434. An ideal cellar should have a uniform low temperature (from 5° to 15°); it should be dry, and be secure from ground-water and ground-air. In practice these requirements cannot in general be perfectly combined.

Care must be taken that the moisture which is thus naturally precipitated on the cold walls of the cellar may be diminished by powerful airing (ventilation) in the cooler season (autumn), but not augmented by the inrush of the moisture of the soil or by ground-water.

As in the construction of cellars the porosity of the masonry is of no importance, and the hardening of moist or wet lime-mortar proceeds very slowly, cement-mortar alone is to be recommended for underground structures, and thus forms a complete protection against water oozing in from the sides.

The floor of the cellar is preferably laid with cement upon a substratum of concrete. But if it does not lie above the highest level of the ground-water, the entrance of the latter can scarcely be prevented even with the best cemented

masonry, and such a structure must be pronounced a total failure.

Warm cellars preserve articles of food badly; potatoes sprout, beer and wine are exposed to decompositions; damp cellars promote mouldiness of the articles stored in them.

§ 435. In general we attempt to prevent the ascent of moisture in the cellar-walls by isolating materials: plates of lead, asphalt, glass, tarred paste-board or cement, in the entire walls as high as the floor of the ground-story.

Sometimes water-proof layers are inserted in the foundation walls, upon which the cellar-walls are erected, below the level of the cellar-flooring. Sometimes the entire cellar-wall is outwardly coated with cement,—arrangements all of which deserve to be recommended.

Determinations of the carbonic acid show if the ground-air has been properly excluded. As the ground-air contains several per cents. of carbonic acid, whilst the open air has only from 0·3 to 0·4 per thousand, a strong influx of carbonic acid is in general easy to recognise. Uffelmann detected in a cellar with a very porous flooring always from 1 to 5·7 per thousand of carbonic acid.

Since the ground-air has been found to be free from microbia, its systematic exclusion has no longer quite the same importance as formerly, when it was dreaded as the introducer of disease-germs. Still, its high proportion of carbonic acid, its moisture and its odour—often bad—are reasons enough for excluding it from the cellar as far as practicable.

It is very judicious to exclude the cellar-air (which is always damp and more or less malodorous) from the house by laying an air-tight stratum of asphalt over the ceiling of the cellar, and causing the cellar-stairs to open direct into the court close to the back-door of the house. A penthouse with lateral screens in case of need covers both doors, and protects any one going into the cellar against bad weather. This may be especially recommended if washing is done in the cellar, as if the cellar-stairs open within the house the rooms are filled with watery vapour and the smell of suds. A disadvantage lies in the insecurity against robbery.

§ 436. Cellar-dwellings must be pronounced anti-sanitary, as they are always damp. For their disadvantages see

§ 438, and Betke (Bibliography). The proposed Imperial law demands that—

The floor of all dwelling-rooms (to be erected in future) must lie above the highest level of the ground-water, and in regions liable to floods above high-water mark.

The floors and walls of all rooms serving for the prolonged abode of man must be secured against ground-moisture.

Dwellings in cellars, *i.e.*, in stories the flooring of which lies below the surface of the ground, are not permissible.

Rooms serving for the prolonged stay of human beings, especially single rooms, may be constructed only on condition that the floor is at most 1 *m.* below, and the opening of the window at least 1 *m.* above, the surface of the earth. Relief from these conditions is permissible if the industrial utilisation of the space requires a deeper situation.

Cellar-dwellings may be made tolerable by deep air-shafts carried outside along the cellar-walls, and if they are provided we may judge more leniently. In this case a porous wall-dressing must be used.[1]

3. Roofs and Roof-Dwellings.

§ 437. The space under the roof (garrets, attics, mansarde-rooms) must always be dry, airy, protected against dust and soot, and their temperature must not fluctuate too extremely.

Roof-dwellings demonstrably present conditions very unfavourable to health, in consequence of their very unsatisfactory thermic relations. It is hence imperative that the roof in inhabited rooms must receive thermic protection by means of quiescent strata of air, and by lining the inner side of the walls with materials which are poor conductors of heat. The examination is conducted in a manner which is at once apparent. In towns where the air is much polluted by soot the demands of free aëration, and of the exclusion of soot, cannot well be simultaneously satisfied.

The most important materials for roofing are at present tiles, slates, sheet-metal, cemented wood, and roofing-paper.

[1] Cellar-dwellings are still too common in England, the only large town where they are (or were lately) entirely absent being Sheffield. In this point the sanitary condition of Paris is much superior to that of London.—*Editor.*

Roofs of straw, reeds, and shingles are disappearing more and more on account of the danger of fire.

A tile-roof, the joints of which are carefully coated with some weather-proof material, presents the advantages of a good ventilation through its pores, tolerable thermic conditions, and moderate expense. It excludes dust and soot. This is not effected by the more airy tile-roofs with joints not coated, nor by slate-roofs on laths.

If a slate-roof lies on a wooden support covered with roofing-paper, the nuisance of dust and soot is entirely at an end, but the ventilation becomes very slight. In this case care must be taken for the ventilation of the wood-work of the roof, or it may quickly fall to ruin.

The latter defect pertains in a still higher degree to sheet-metal roofs, which must be considered hygienically objectionable on account of their unfavourable thermic properties.

If the attic story contains rooms for permanent occupation, roofing with wood and cement is greatly to be recommended, as it affords extremely favourable thermic conditions at a moderate cost. At the same time, it has the advantage that the rooms have nearly horizontal ceilings, whilst the flat roof can serve as a resort in the evening after sultry days whilst the rooms are still heated.

A roof of roofing-paper takes a very subordinate place for dwelling-rooms, but it is very extensively used for factories, barracks, &c. It also requires ventilation of the beam-work, and whitewashing as a protection against heat.

In all air-tight kinds of roofing the ventilation is to be considered as necessary if it has below a wooden lining or a coating of mortar. If the air can play round the beams below, the occasional aëration of the rooms in question is sufficient for the preservation of the woodwork.

4. The Walls.

§ 438. 1. *Dampness of the Walls.*—For accurate examination (after removing in case of need a piece of the paper-hangings) we bore a hole with a steel gauge-chisel through the entire thickness of the wall-plaster, if possible over a joint of the mortar. We collect the mortar in a glass with a caoutchouc stopper; we then bore deeper into the mortar at a joint (to about 5 *cm.*), and collect this also in a separate glass. We then effect in each specimen a determination of the water and quicklime, according to § 431. For an accurate decision we should take specimens of the plastering

and the wall-mortar at different parts of the room, two at least. There are hitherto no methods for this purpose which do not injure the paper-hangings. Hygrometric examinations of the air yield very uncertain results. The sound of the mortar on tapping, the touch on feeling it, and ocular inspection are all but doubtful auxiliaries, thus, *e.g.*, a cold wall always feels moister than one which is warm.

If it is required to determine the source of the water, attention must be given to the fact that—

1. The house has been damp from the beginning.
2. The house was only superficially dry when first occupied; the places which are now remarkably damp are to be referred to the condensation on the cold walls of gaseous water as it is exhaled by the inmates, and by every particle of linen hung up to dry. This case may be observed every winter in many cellar dwellings.
3. Condensed water on cisterns of cold water (sweat-water, as called by masons) may render the rooms damp in which the cistern is placed.
4. The water may be derived from leaky pipes, or from defective roofing, or, in time of rain, from windows which do not fit tightly.
5. The walls on the weather-side may be so thin that they allow rain, which beats against them, to penetrate, and they are not protected with a coating of slates, shingles, or roofing-tiles.
6. The moisture is ascending ground-water. This case is the most unfavourable; it shows that the foundation-walls extend into the ground-water, or into wet strata of earth, without the introduction of materials impervious to water. A remedy is here difficult.

For deciding these questions no particular methods are required, merely a careful examination and a consideration of all the conditions.

As soon as extensive damp spots are observed in several places, and perhaps water oozing down, and vegetations of mould upon paper-hangings, articles of leather, &c., and suitable measures[1] do not at once remove the mischief, the house must at once be considered as dangerous to health.

Articles of food (bread, meat, &c.) become mouldy in a damp atmosphere much more readily than in dry air.

Good dry walls contain not more than from 0·4 to 0·6 per

[1] The presence of calcium chloride and nitrate in the mortar promotes renewed dampness, as these salts are very hygroscopic. They are introduced by the use of water containing chlorides and nitrates, or by the infiltration of sewage into the building, from which it cannot again be removed.

cent. of free water. New buildings, according to K. B. Lehmann and Nussbaum, may be regarded as dry if the entire mortar does not contain more than 1 per cent. of water.

If the moisture reaches 4 or 5 per cent. it is perceptible to our feeling.

At what proportion of moisture hygiene should sanction the occupation of a newly-built house can only be determined by the aid of further data. For the present, 1 per cent. may be regarded as a limit to be aimed at. In any case, in a house with rational arrangements for heating and ventilation —and with the guarantee that these are used—we may be rather more lenient. I consider 1·5 to, at the outside, 2 per cent. the utmost limit.

It cannot be denied that houses with proportions of moisture evidently not inconsiderably higher are taken into occupation. The unpleasantness and the danger to health of drying a house by living in it are universally known. Firstly, damp walls are good conductors of heat in winter, and are therefore cold (danger of taking cold); secondly, a quantity of water in the walls is a preliminary condition for a growth of micro-organisms in or upon them; and, lastly, the presence of water in paper-hangings renders possible a development in them of arseniuretted hydrogen. Infectious diseases, tuberculosis, malaria, are frequent in damp houses, and articular rheumatism and chronic diseases of the kidney demand numerous sacrifices, though we have not yet reached a clear understanding of the connection.

Authors have also, certainly, expressed an opposite opinion. Edlefsen cannot recognise any connection between articular rheumatism and damp dwellings, although this disease appears strikingly accumulated in many houses (Fourth Congress for Internat. Med. in 1885). Hüllman (*Deutsche Vierteljahrschrift für öffen. Gesundheitspflege*, 1885) finds the occupation of damp newly-built houses quite harmless if there is sufficient ventilation, with the addition of an aspect open to the wind, and he supports this opinion with rather copious statistics. Notwithstanding these results, the greatest caution appears to me to be for the present our duty.

§ 439. 2. The best known and most dreaded disease of timber is caused by the house-fungus (*Merulius lacrymans*).

It is developed chiefly in damp wood excluded from air, *e.g.*, on the under side of flooring-boards which lie upon moist earth without an isolating stratum of air, on beam-heads built into walls, &c.

In our forests the house-fungus very rarely occurs, it is almost always introduced from other structures (wood from infected buildings, the shoes and tools of the workmen, wood from infected sheds, &c.).

House-fungus is recognised by its mycelium, which in its earliest stages forms whitish, woolly, cobweb-like flocks, but afterwards forms thicker layers, lines, or cords of a whitish-grey, afterwards ash-grey colour and strong lustre. (For the microscopic peculiarities of the mycelium, see Hartig.) Under favourable conditions the fungus grows with enormous rapidity—grows over or through stone and ironwork by means of long tough extended lines, and forms ultimately, where the mycelium arrives at daylight, flat, expanded, leathery, plate or console-shaped fruit-bearers of a yellowish-brownish or brownish-red colour, from 5 to 30 *cm.* in diameter, supporting a dark brown layer of fruit. The latter displays wide wavy pores of an irregular shape, and emits clear drops; the spores, which fall out in masses, are of a cinnamon-brown, oval, bicellular.

House-fungus sometimes betrays itself before it comes visibly to light by the damp smell of the rooms (the putrefying fruits emit a very offensive smell), by the sinking in of parts of the floor which are heavily burdened (near the stove), and by the cessation of vibration. The last symptoms are due to the circumstance that the wood loses a large part of its mineral constituents, of its cellulose and its coniferine, and therewith forfeits its elasticity and firmness. The wood loses as much as a quarter of its bulk and the half of its weight, and in a dry state it becomes friable. At the same time its power of absorbing water increases threefold.

Hartig has recently shown that, along with *Merulius lacrymans*, other fungi (e.g., *Polyporus vaporarius*) effect the destruction of wood most rapidly, attacking it even in the forest.

Polyporus vaporarius forms a snow-white mycelium which does not turn grey even with age, and scarcely apparent white fruits with small pores. It attacks only moist wood, as its cords have not the power of transferring water from damp to dry parts of a house.

A disease of wood known as "red stripiness" destroys timber without any externally visible mycelium. In its highest degrees it is known as dry rot. We speak also of a "suffocation" of timber. We now know these affections also are determined by pileate fungi; and *Polyporus vaporarius*, as well as the true house-fungus, may be the cause. Other fungi which behave in a similar manner have not been as yet sufficiently investigated. The more developed diseases of timber in a house must be judged very severely. The safety and the agreeableness of the dwelling suffer very considerably; remedies are difficult and costly, and there is always danger that the house may become totally useless. Fungi are further a sign of deficient dryness of the rooms; indeed, rooms which were previously dry may be made damp again by house-fungus.

Besides the indirect injuries, Ungefug alleges (*Viertcljahrschrift für ger. Med.*, vol. xxvii., &c., Bibliography) that he has observed attacks of disease in a family who lived in a house very strongly attacked with fungus. The symptoms were not characteristic, fever, constipation, catarrh of the respiratory organs; spores were abundant in the sputum. For the present the connection between the illness and the fungus seems to me by no means free from doubt, such affections would otherwise be observed more frequently. The presence of spores in the sputum is not necessarily connected with any hurtfulness of the spores.

HARTIG, R. *Der echte Hausschwamm.* Berlin. 1885. Two lithographic plates.

HARTIG, R. *Lehrbuch der Baumkrankheiten.* 2nd edition. Berlin. 1889. With 137 figures in the text and a plate in chromo-lithography. Contains further bibliography.

§ 440. 3. *Wall-colours and Paper-hangings.*—The coating of the walls deserve our attention on several grounds.

Whilst lime-colours scarcely interfere with the porosity of the walls, and consequently with ventilation through the pores, size-colours, paper-hangings, and oil paints are in an ascending series hindrances to the exchange of air and the transfer of water. Walls coated with plates of stone, or imitations of stone, leather-hangings, &c., exclude the air almost absolutely. For an accurate determination of the ventilation through the pores we proceed in any given case as in § 117. Wainscoting of wood is now always applied so as to be at a distance of from 3 to 5 *cm.* from the wall, and affords apertures at top and bottom for the change of air; otherwise it warps, splits, &c. In this state it does not at all interfere with the interchange of air.

For paper-hangings the search for arsenic is often very important (see Section XVIII.).

Esmarch undertakes a bacteriological examination of walls by rubbing a surface of 25 *scm.* with a piece of fine sponge about the size of a bean, previously sterilised by boiling in water. The sponge with the adhering fungi is then worked up to a roller-plate. For the application of this method to comparative enumeration, see the original (*Zeitsch. f. Hygiene*, vol. ii.). The presence of caustic lime in the walls certainly prevents any development of microbia for a very long time. Washing with lime-water destroys all.

For the detection of the bacilli of tubercle, collected dust or scrapings of the plaster, or the washings of paper-hangings, &c., are introduced into the peritoneal cavity of guinea-pigs (§ 75). See Cornet (*Zeit. f. Hygiene*, v.), "The Distribution of the Bacilli of Tubercle outside of the Body."

5. Floors and Ceilings.

§ 441. Floors should be smooth, not splintery, lasting, and, above all, well joined, so as completely to shut off the false bottom.

Different woods are suitable for floors in the following decreasing order: oak, impregnated red beech, white beech, ash, American pitch pine, Scotch fir, pine. The boards should be dove-tailed to each other, and either be laid in asphalt or lined below with impervious roofing-paper.

Beneath the flooring there follows in "parquet" and

"band" floors[1] a dead floor constructed of ordinary but sound planks; the space between the latter and the plank of the ceiling of the room below is filled in its upper half with some porous material, a bad conductor of heat and sound, and as safe as possible in case of fire; the lower half is left void.

It is important to ascertain what material has been used for the false flooring. Along with the above-mentioned properties such flooring must be free from damp, from nutritive media, from inferior organisms, and from unappetising or disgusting materials.[2]

Instead of washed, dry sand and gravel, dry clean building rubbish, and other indifferent materials, Emmerich discovered the use of incredibly filthy matter. The examination is conducted like that of soils (§ 157), the most interesting points to be determined being chlorine, nitric acid, nitrous acid, and ammonia. The mouldy, putrescent smell of such materials, and even of entire dwellings where it has been used, puts us on the track. An examination of the rubbish taken out will generally render an analysis superfluous.

Emmerich was also able to detect considerable increases of temperature in the dirty matter filled in between the floor and the ceiling. Such increases are due to the vital processes of micro-organisms, and are detected by the introduction of thermometers. He further detected the increase of carbonic acid in the air of uninhabited rooms, and lastly (*Arch. f. Hygiene*, vol. ii.), by the culture Friedländer's coccus of pneumonia from the false floor of a hall in a prison during an epidemic of pneumonia. Heinzelmann repeatedly detected the bacilli of tetanus in false floors at Munich. The examination scarcely requires special methods; for the details we may refer to the works cited. More particular instructions as to how a material for false bottoms is tested as to its hygienic properties, and also as to the deadening of sound, may be found in Nussbaum (*Arch. f. Hygiene*, v.).

The decision upon any impurities detected in a false bottom must, according to what has been said, be absolutely strict. Polluted material is at once repulsive and hurtful to health, and must be replaced by clean substances.

For a decision on odours see sewer gases.

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[1] Kinds of flooring not usual in Britain, and for which no distinctive English word exists.—*Editor.*

[2] This description of the intermediate floors of a house is quite inapplicable to the constructions ordinarily used in England.—*Editor.*

Ventilation (of the beam-heads) is necessary for the timbers if they are not to fall to early destruction. In this respect panel work has advantages.

6. Windows and Doors.

§ 442. Windows and doors must close well, and the former should always admit of opening. It is very judicious to provide them with a trap arrangement (capable of revolving on a horizontal axle). Double windows are a protection against the cold in winter, and to some extent against heat in summer. They are also a security against dust and the noise of the streets. For simple windows double glazing (the two panes placed at an interval of 7 *cm.*) from each other afford a similar protection.

Except at the northern sides shutters or lattices outside the glass windows are necessary to exclude the summer sun.[1] Interrupted shutters with louvre boards are now generally used, which render it possible to keep the rooms cool, though at the expense of the light. All curtains, blinds, &c., inside the windows serve merely as a protection against light; as a security against cold their action is very imperfect.

IV. Illumination, Natural and Artificial.

A. Natural Illumination.

§ 443. Rooms for prolonged occupation should, according to the proposed imperial law, have a window-surface $= \frac{1}{7\frac{1}{2}}$ of the surface of the floor.

For schools one-fifth is generally demanded; Tischler considers one-seventh sufficient for village schools as a moderate demand. In schools, offices, &c., the light should enter only from the left, though a slight simultaneous illumination from the right does little harm. If light is introduced from the front it dazzles the pupils, and if from behind the teacher. The depth of the rooms, and the more

[1] Scarcely so in England.—*Editor.*

or less free position of the house, come here prominently into consideration. In the upper rooms smaller windows suffice than in the lower. The position of the house with respect to the cardinal points is important. In a northern aspect the diffused light can be fully utilised. In the other directions curtains are required, which should be thin and of a light colour—by preference white or pale grey.

For private houses the darkening action of thick curtains must be taken into account, as they especially screen the upper part of the window, which is optically the most valuable. All decorative curtains should be placed as far as possible in front of the wall, and not of the surface of the window. The colour of the ceiling, of the walls, of the floor, of the stove, and of the furniture is important; a light colour for the walls, which reflects light well, is especially desirable for north rooms if they are intended for work.

For an objective decision on the amount of illumination with daylight of a given spot, L. Weber has devised his room-goniometer. See *Dingler's Polyt. Journal*, vol. cclix. p. 122. A short description with a figure is found in *Uffelmann's Handbuch der Hygiene*, p. 26. Fifty square degrees on a dull day = about 10 metre-candles (see § 447).

Weber's photometer, to be described below, may be used for measurements of daylight (§ 447).

For calculating the intensity of the illumination of rooms before they are completed, Karl Mohrmann gives instructions (*Ueber die Tagesbeleuchtung innerer Räume*).

B. Artificial Illumination.

1. EXAMINATION OF AND DECISION ON LIGHTING MATERIALS.

Coal-Gas.[1]

§ 444. Examinations of coal-gas presuppose an acquaintance with gas analysis, for instruction in which the reader must be referred to the works of Hempel and Winckler referred to

[1] For the mean composition of coal-gas we find very conflicting statements, *e.g.*:—

	Heavy Hydrocarbons, Ethylene, &c.	Light Hydrocarbons, Marsh-Gas, &c.	Carbon Monoxide.	Hydrogen.
Rubner . . .	3·5 per cent.	36·2	9·1	50·2
Uffelmann . .	5·7 „	59·5	4·5	30·0

in the bibliography of the section on air.[1] This especially refers to the quantitative determination of carbon monoxide (see § 134), which is hygienically the most important constituent of coal-gas. Such gas, how brilliant soever may be the illumination it produces, is bad hygienically if its proportion of carbon monoxide exceeds from 5 to 7 per cent. Unfortunately proportions of 10 per cent. are often found. "Water-gas" with about 30 per cent. of CO is absolutely inadmissible for private houses; in manufactories and smelting-works, where there are better guarantees for well-fitting piping, and for circumspection in the use of so dangerous a compound, it may be used, but with caution.[2] In comparison with carbon monoxide the toxicity of all the other ingredients of coal-gas entirely vanishes. Sulphuretted hydrogen ought to be absent, as it burns to sulphurous acid. Carbon disulphide, and more complicated organic compounds of sulphur, should be present only in the minutest possible traces. An examination of the gases escaping from a burner which has "struck back" readily shows, on applying lead paper, sulphur in organic combinations, which is thus converted into H_2S (*Chem. Zeit. Repertorium*, 1891, p. 6). For the luminous power the proportion of benzene is especially important, along with it ethylene, propylene, and butylene, the heavy hydrocarbons.

The odoriferous constituents of coal-gas (acetylene, the higher hydrocarbons, such as naphthaline, organic sulphur compounds) betray the danger of poisoning by carbon monoxide only when the escape passes free into the air. If a street main is broken the soil at first absorbs the odoriferous substances perfectly, but subsequent portions passing through the same soil give off a peculiar aromatic odour, and not until the absorbent power of the earth is exhausted does the true smell of coal-gas make its appearance. In winter especially

[1] The examination by means of Bunte's burette is sufficient for most purposes, and is well and fully described by Leybold (*Journal f. Gasbeleuchtung*, 1890, p. 233).

[2] It is not sufficiently known that by a simple process invented by the editor the carbon monoxide may be completely removed from water-gas.

coal-gas may diffuse itself 30 *m.* and more in the soil from a ruptured pipe, and into heated houses, which often may themselves not have any gas piping laid in. If the escape of gas is not perceptible to the smell, CO may be detected by the methods given in § 134. Or some white mice may be placed in a cage in the locality to be examined, and if they die their blood may be examined for carbon monoxide.

It may be very important to seek out defective places in gas-piping; this is done by approaching them with a candle, and thus rendering any escaping gas visible by ignition. For this purpose the light must not be too strong, and as a matter of course in a room into which gas has already escaped in quantity, such investigations can only be undertaken after a thorough ventilation on account of the risk of explosion and of poisoning. If a gas-pipe has burst underground, the search for the faulty part by digging down and trying with a light is often difficult and depending on accident. Coal-gas explodes violently if mixed with from five to eight parts of air. Hollow rods are thrust down in the direction of the gas-pipe at distances of from 1 to 3 *m.*; the gas issues from the rods near the damaged place, and is recognised by its odour and by ignition.

Gas-burners may often be judged by the eye without any testing. In those of improved construction the heating and contamination of the air and the expense decrease *pari passu* with the increasing utilisation of the luminous power.

The slit-burners are to be regarded as quite injudicious; very similar are the fish-tail burners; much better are the Argand burners, provided with many fine apertures for the escape of the gas. Here a much higher temperature of the flame and a greater luminosity are secured by a lamp cylinder. Very much preferable are the recently devised systems in which both the coal-gas and the air supplied are warmed previously (regenerative, intensive burners, &c.). See § 447.

Petroleum.

§ 445. American petroleum in its crude state[1] consists of a mixture of very numerous hydrocarbons, chiefly of the formula C_nH_{2n+2}, *i.e.*, belonging to the marsh-gas series.[2] By fractionated distillation the mixture is resolved into petroleum ether (boils at from 40° to 70°), gasoline (70° to 80°), petroleum naphtha C = petroleum benzine (80° to 100°), petroleum naphtha B = ligroin (100° to 120°), petroleum naphtha A (120° to 150°), then in petroleum distilling from 140° to 150°, and up to 300°, and lastly, heavy oils, lubricating oils boiling above 300°.

According to Thörner, a petroleum containing more than 6 per cent. of oil distilling below 140° is to be objected to as dangerous. If it contains more than 8 per cent. of substances volatile above 310° its luminous power is decreased in an undue manner.

In Germany an Imperial law of February 24, 1882, prescribes that petroleum which, at a barometric pressure of 760 *mm.*, gives off inflammable vapours at a temperature below 21°, may be sold only with special precautions, and must be labelled as dangerous.

For determining the flashing-point of the vapours, the employment of Abel's petroleum-tester is obligatory. Since each instrument is accompanied with a full description, with illustration and tables, the following general remarks may suffice :—

The petroleum, refrigerated before the experiment down to 12°, is introduced into a brass cylinder up to a mark. It is suspended about half full in an air-bath, which is heated by a surrounding water-bath. The latter is filled at first with warm water at 58°, and kept at 55° during the experiment by means of a spirit-flame. The petroleum vessel closes with a lid ; a spring which is drawn up each time on pressing a button permits the following action. A slide in the lid of

[1] Various important matters on the purification of petroleum, apparatus for testing, &c., may be found in a paper by Kissling (*Chemiker Zeitung*, 1890, No. 68).

[2] Hydrocarbons of the ethylene, naphthene, and benzene series may also be found in small quantities. Caucasian petroleum behaves quite differently.

the brass cylinder opens for two seconds, and at the same time the flame of a very small lamp burning on the lid lowers itself into the internal space of the petroleum vessel. As soon as the vapours have reached a certain density there appears a bluish flame of short duration.

We begin testing at lower or higher temperatures, according to the barometric pressure (*e.g.*, at from 715 to 725 *mm.* at 15·5°, at 745 to 755 at 16·5°), as the development of vapour is promoted by a low barometric pressure. As soon as the thermometer has risen ½° the experiment is repeated until a distinct blue flame flashes up.

The temperature of ignition thus is re-calculated for the normal height of the barometer, 760 *mm.* The following figures are a brief extract from the table which accompanies the instrument.

Height of barometer	710	720	730	740	750	**760**	770	780
Degrees Centigrade	17·3	17·6	18·0	18·3	18·7	**19**	19·4	19·7
	18·3	18·6	19·0	19·3	19·7	**20**	20·4	20·7
	19·3½	19·6	20·0	20·3	20·7	**21**	21·4	21·7

and so on to 25°.

Consequently, if a petroleum flashes at 730 *mm.* of the barometer, at 19·0°, its flashing-point for the normal barometric level of 760 *mm.* is at 20·0°.

Petroleum, which does not meet the very moderate German requirements, is scarcely met with in trade, but according to Elsner there are often good and cheap sorts of petroleum with a flashing-point of 40° Abel. The "Kaiseröl" (imperial oil) in such general use gives an Abel test of 42°. The hygienist will rarely use the instrument.

The hygienic decision on the construction of lamps has to consider that round burners generally give a more convenient illumination than flat burners (§ 447), though there are recent flat burners of very judicious construction and very considerable illuminating power, so that a direct examination according to the principles laid down in § 447 cannot be dispensed with. A danger of explosion scarcely exists with the more recent construction of lamps and the judicious use of superior qualities of petroleum, as the latter are in general even much less inflammable than the law requires.

The vacuum formed in the oil-holder by the consumption of the petroleum becomes gradually filled with petroleum vapour and air. Explosive mixtures can be formed only under two conditions :—

1. The petroleum has been badly purified, so that it emits explosive vapours without being strongly heated.

2. Conditions occur in which the vapours produced are abnormally heated:

a. Another burning lamp is placed below the oil-holder of a burning suspended lamp.

b. By occlusion of the air-holes in the perforated gallery of the brass cylinder, so that the upper parts of the burner are imperfectly cooled.

c. Particles of wick which, when the lamp has been carelessly trimmed previously, have fallen upon the plate of the burner-tube (the transverse closing of the inner free space of the burner-socket of an annular burner), and have become ignited so as to heat the petroleum-holder.

But for these explosive vapours really to explode, air rich in oxygen must be mixed with them, which cannot readily occur without the oxygen being first consumed, except in wide burner-sockets not sufficiently filled by the wick. A defective nature of the wick is therefore a main cause of explosions.

The petroleum vapours are less frequently ignited when, on carrying the lamp, the hot upper oil-receiver comes suddenly in contact with the cold petroleum and breaks.

2. EXAMINATION OF AND DECISION ON THE QUANTITY OF LIGHT FURNISHED.[1]

§ 446. We express the luminous power (strength of light) of any given source of light by comparing it with the "normal candle," which is taken as a unit.

Unfortunately the most different sources of light are still used as normal candles. Those best known in Germany are:

The German Union paraffine candle[2] consumes, when the flame is 50 *mm.* in height, 7·7 *grm.* paraffine (congelation-point, 55°) per hour, and yields an intensity of light 1·224 (weight of a candle, 50 *grm.*).

The Munich stearine candle consumes, for a flame 50 *mm.* in height, from 10·2 to 12 *grm.* stearine, and yields a light of the intensity of 1·135.

The amyl-acetate lamp of Von Hefner Alteneck yields, for a flame 40 *mm.* in height, a light of the intensity of 100. It is considered the most constant source of light. See the critical researches of Löwenherz and Drehschmidt (*Journal f. Gasbeleuchtung*, 1891, No. 34). A

[1] On the "illuminative power of lamp-shades" see the thorough investigation by H. L. Cohn, Wiesbaden, 1885.

[2] This candle may be known by a red thread in the middle of the wick.

chief difficulty consists in procuring amyl-acetate of unitary composition.[1]

The height of the flame must be often measured with a wire fork, the points of which are fixed exactly at the distance required (40 or 50 *mm.*). If the flames are too high, the wick must be carefully shortened.

The determination of the intensity of the light is generally effected by means of the Bunsen photometer. For approximate determinations, as they suffice for hygienic purposes, this instrument may be simply improvised by means of a rib of wood 2 *m.* long, graduated in centimetres, upon which a paper screen can be caused to slide. On the middle of the screen there must be a grease spot.

The intensity of the illumination of the screen by two sources of light, to the left and the right, is equal when the grease spot disappears if viewed from both sides, *i.e.*, when it appears as bright as the parts of the screen which are not greased. When this point is reached, if the sources of light are at unequal distances from the screen, their intensities are inversely as the square of the distances from the screen.

In a practical experiment the flame of the normal candle and the source of light under examination are placed in a darkened room at the same level to the left and the right of the screen. The screen is then displaced upon the rib until the grease-spot disappears, when the distances of the sources of light from the screen are read off. If in one experiment the grease-spot disappears when the normal candle was at the distance of 50 *cm.* from the screen, and the lamp to be compared with it at 150 *cm.*, the intensities of the lights are as :

$$1 : x = 50^2 : 150^2, \text{ i.e., } x = \frac{2250}{250} = 9.$$

The light has the luminous power of nine normal candles.

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[1] The relation of the German normal candle to the English normal candle and the French carcel is, according to Schilling :—

German Candle.	Munich Candle.	English Candle.	Carcel.
1000	887	977	102
1128	1000	1102	115
1023	907	1000	104
9826	8715	9600	1000

See Wagner's "Chemical Technology," English edition, edited by W. Crookes, 1888, p. 96.

If we consider the illuminative material consumed in an hour (the weight in case of candles, petroleum, &c., and the volume as measured by the meter in case of gas), we can readily ascertain the hourly cost of the various illuminants per 100 normal candles.

Simple as are the principles of these measurements, it is difficult to obtain absolutely correct values. For this purpose there are required dark rooms, costly photometers, accurately constructed, and with an auxiliary flame at the screen to correct the absorption of light by the latter, the greatest attention to the normal candles, &c. (see Rubner, *Lehrbuch d. Hygiene*, p. 230).

§ 447. If the hygienist wishes to procure an apparatus for the measurement of light, the photometer of L. Weber is preferable to all others. It permits not only a measure-

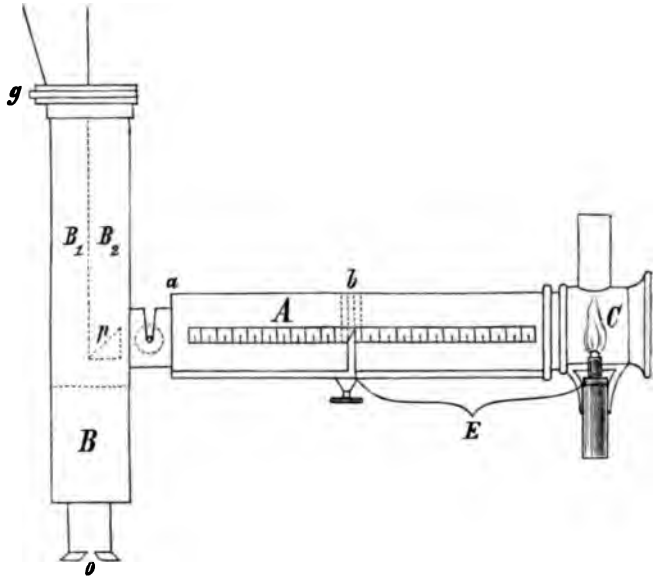

FIG. 125.—Leonhard Weber's Photometer.

ment of the intensity of sources of light, but of the degree of illumination of an object, *e.g.*, of a sheet of paper, whether by diffused daylight or by artificial lights—which is hygienically of especial importance.

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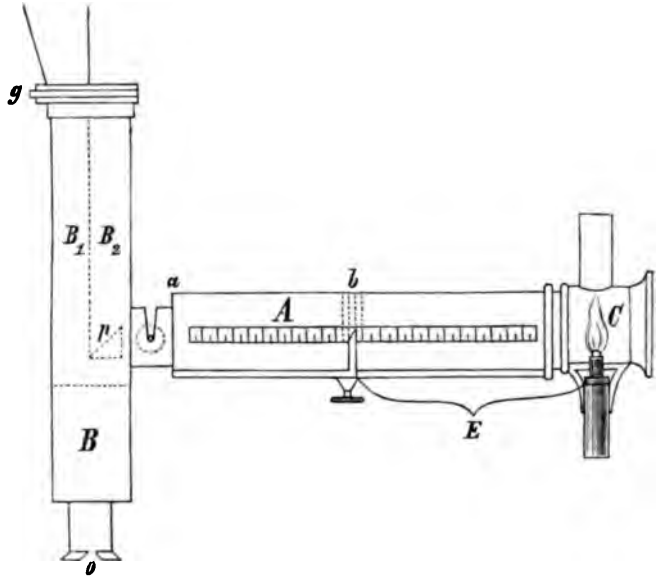

FIG. 125.—Leonhard Weber's Photometer.

ment of the intensity of sources of light, but of the degree of illumination of an object, *e.g.*, of a sheet of paper, whether by diffused daylight or by artificial lights—which is hygienically of especial importance.

A minute description of the apparatus would take us too far, and is also needless, since each such apparatus supplied by the firm Schmidt & Hänsch is accompanied with a pamphlet which completely explains its use. The principle of the apparatus is as follows:—

Into the metal tube *B*, graduated longitudinally, there fall lights of two kinds. On the one hand light from the benzene burner *C*, capable of being accurately regulated. This light passes at *b* through a displaceable plate of opal glass, and at *p* is entirely reflected into the right half of the field of vision of the eye-piece at *o*. At the same time, light from the object to be examined falls through the left-hand half of the tube *B*, passing generally also through a plate of opal glass at *g*. The nearer *b* is to *C*, the brighter is the right-hand field of view, and the nearer *b* is to *a* the darker is the right-hand field. By a suitable displacement of *b*, both halves of the field of vision can be made exactly equally bright.[1]

For absolute measurements the strength of the benzene burner, *C* (approximately one normal candle), must be exactly known, and it must also be known to what extent the several plates of opal glass weaken the light.

a. Use of the Apparatus as an Ordinary Photometer.

Determination of Constants.—For this purpose we place a normal candle (or a Hefner-Alteneck amylacetate lamp) at a known distance from B_1 (50 *cm.*), and displace *b* until the illumination on the left and right is equal.

We have now on the left: strength of the source of light = 1, distance from the opal-glass plate at $g = 50$ *cm.* Suppose that the opal glass at *g* allows $1/x$ of the incident light to penetrate. On the right we have: strength of the source of light = 1, distance of the displaceable plate of opal glass from $C = E$. Suppose that this plate transmit $1/y$ of the incident light.

$$\text{Then } \frac{1}{50^2 \times x} = \frac{1}{E^2 \times y}, \text{ therefore } \frac{x}{y} = \frac{E^2}{50^2} = K.$$

K therefore is a constant to be especially calculated for every plate

[1] Recently the construction of the field of vision has been improved, so that by the use of a Lummer prism the two fields of vision lie not side by side, but concentrically, the one within the other.

of opal glass which is to be inserted at *g*, and which is supplied by the maker along with the apparatus. For determining the intensity of very powerful sources of light, several plates of opal glass may be introduced simultaneously at *g*.

Execution of a Measurement.—If an unknown source of light of *m* normal candle-power is to be compared with the Weber benzene normal burner, we set it at an arbitrary distance from *g*,—*e.g.*, 60 *cm.* If $E = 21$ *cm.* for an equality of light, then :

$$\frac{m}{60^2 \times x} = \frac{1}{21^2 \times y}, \text{ therefore } m = \frac{60^2}{21^2} \times \frac{x}{y}, \text{ i.e.} = \frac{60^2}{21^2} \times K.$$

If the two sources of light have different colours, equality of light is not obtained at any position of *b* ; we therefore insert into the eye-piece a red and afterwards a green glass, and thus determine separately the intensity for the red and for the green rays. On this subject and on the application of the values, see the description which accompanies the instrument.

b. Use of the Apparatus for Determining the Intensity of the Light which Illuminated Surfaces emit in Metre-Candles.

1. If a matt white surface is illuminated by the flame of a normal candle, a spot which lies at the base of a perpendicular let fall upon the surface receives, according to L. Weber's definition, the luminous intensity of a *metre-candle*. If we allow this light to fall into the left compartment of our apparatus, and displace *b* until the lights are equal, we obtain a new constant, with which we may test surfaces of paper illuminated at pleasure.

The constant is obtained on the simple assumption that the paper reflects $1/x$ of the light, and that the displaceable opal glass plate transmits $1/y$ as before, when equality of light prevails at the distance *e* of the slide from the candle.

$$\frac{1}{100^2 \times x} = \frac{1}{E^2 \times y}; \quad \frac{E^2}{100^2} = \frac{x}{y} = K_1.$$

For carrying out an experiment light is thrown into the left compartment of the apparatus from a sheet of paper, the unknown intensity of which (*m* metre-candles) we wish to test from a known distance (*e.g.*, 50 metres), then, if equality of light exists at $E = 28$,—

$$\frac{m}{50^2 \times x} = \frac{1}{28^2 \times y}; \quad m = \frac{50^2}{28^2} \times \frac{x}{y} = \frac{50^2}{28^2} \times K^1.$$

In examining a very bright light a plate of opal glass must here also be introduced at *g*, which modifies the constants accordingly.

2. Instead of regarding an illuminated sheet of paper, we may put

exactly in its place the mouth of the tube B_1 itself, closed with a plate of opal glass. In calculating the constants we have then merely in place of $1/x$ (the quantity of light reflected by the paper) to take $1/x_1$, *i.e.*, the quantity of light transmitted by the opal glass. With the aid of the constant K_2 thus obtained, we proceed exactly as explained under 1.

Hermann Cohn demands for workrooms the following intensity of the illumination of the paper: if possible an illumination of 50 metre-candles, and as a minimum 10 metre-candles, whether in case of artificial or of natural illumination. The ordinary lamps give 10 metre-candles only at a distance of $\frac{1}{2}$ *m.*, but the intensity of the lighting can be enormously increased by screens and reflectors properly applied.

3. HEATING AND POLLUTION OF THE AIR BY SOURCES OF LIGHT OF DIFFERENT STRENGTH.

For a general view it is sufficient to examine the following table by E. Cramer (the consumption of materials according to E. Fischer):—

	100-CANDLE ILLUMINATION.			
	Consumed.	Produced.		
	Materials.	CO^2.	Watery Vapour.	Heat.
	Cbm.	*Kilos.*	*Kilos.*	*Calories.*
Gas, Siemens regenerative lamp	0·35	0·386	0·304	1843
Gas, Argand burner	0·80	0·882	0·694	4213
	Kilo.			
Petroleum, small flat-burner				
3 hours' experiment	0·60	1·648	0·635	6220
8 hours' experiment		1·876	0·762	
Petroleum, large round burner				
3 hours' experiment	0·20	0·549	0·218	2073
8 hours' experiment		0·625	0·254	
Paraffine	0·77	2·298	0·911	7615
Stearine	0·92	2·443	0·936	7881
Tallow	1·00	2·681	0·941	8111

It follows that the solid illuminants (especially tallow) occasion by far the greatest inconvenience by the production of carbonic acid, of watery vapour, and by the liberation of heat. For gas and petroleum everything depends on the construction of the lamps. Well-made petroleum lamps are scarcely inferior to the best gas-burners; bad petroleum

lamps are worse than Argand burners, but still much better than slit-burners, which, according to E. Fischer, contaminate and heat the air from two to three times as strongly as Argand burners.

In order to compare the pollution of the air in a given case, *e.g.*, in a theatre with gas and electric lighting, an experiment has to be made with the different illuminants both in a full and an empty house, determining the carbonic acid and the temperature (if needful), also the atmospheric moisture at different points and at different times after the beginning of the lighting. The temperature in the open air, the ventilation, the strength of light, the number of the audience should, of course, be as uniform as possible if the observations are to be mutually comparable. The results are plotted out graphically and compared with each other and with the requirements in § 151. As a pattern for such investigations see Renk's work mentioned in the Bibliography.

The pollution of the air by the products of imperfect combustion, hydrocarbons, carbon monoxide, nitrous acid, nitric acid, &c., can be determined quantitatively only by experienced chemists. But little on this subject is available. Erismann made use of the following method:—The air to be examined is passed through potash bulbs to remove the carbonic acid, and then through a combustion-tube filled with ignited copper oxide. There is thus carbonic acid formed from the hydrocarbons, and it is again taken up in absorption apparatus (Pettenkofer's baryta tubes) and titrated. 44 *mgrm.* carbonic acid correspond to 16 *mgrm.* of marsh-gas, CH_4. E. Cramer disapproves of this method; he ascertained by complicated experiments that from 1 *grm.* of illuminating material burnt there are formed from 0·64 to 0·85 *grm.* carbonic acid, whilst from 5 to 107 *mgrm.* carbon is eliminated as such (soot), or is imperfectly burnt. The combustion is most imperfect in experiments of short duration with petroleum slit-burners; a large part of the soot is deposited on the wick or on the burner, to be again burnt in the further course of the experiment.

Hyponitric acid always occurs; in contact with water it is converted partly into nitrous and partly into nitric acid. Quantitative experiments not yet concluded yielded per 1 *grm.* stearine a formation of quantities of NO_2H up to 0·322 *mgrm.*; the nitric acid formed simultaneously is not determined.

The air in Cramer's own experiments was rendered transiently unpleasant to the nose by from 1·5 to 3·6 (on an average, 2·2) per 1000 parts of carbonic acid. This was certainly occasioned by the traces of nitrous acid. However, the initial sensation of dryness in the nose was quickly tolerated. A stay of two hours in air containing from 4 to 5 per 1000 of CO_2, generated by the combustion of coal-gas, had no permanent effects. Some SO_2 is probably never absent in the products of the combustion of coal-gas.[1]

APPENDIX I.—ELECTRIC LIGHT.

§ 448. The electric glow-light produces no carbonic acid, no other substances which contaminate the air, and very little heat. The arc-light develops about 1 per cent., and the glow-light 6 per cent. of that given off by an Argand burner of the same illuminating power.

The works cited in the Bibliography develop in full the plan of experiments by which may be shown the superiority of the electric light over other sources of light in the examination of lighted buildings. It is essential for the observer to have the building quite at his disposal several times; on one occasion when filled with people, and on another when empty, but in any case once when lighted with gas, and once when illuminated electrically. Numer-

[1] It must not be forgotten that the products of the combustion of the common illuminants differ not merely in quantity but in quality. Sulphurous acid has never been detected as given off in the combustion of stearine, paraffine or tallow candles, nor of properly refined petroleum. It is present to a serious extent in the products of the combustion of coal-gas, as is shown by its action upon plants, books, pictures, curtains, articles of metal, &c. These injuries do not occur if some other source of light is introduced in place of gas.—*Editor.*

ous determinations of carbonic acid, of moisture, and of temperature at various points of the locality, and at equal intervals from the beginning of the experiment, quickly give a clear view of the comparative conditions. The lustre of the electric light may be disturbing; the carbon filament of a glow-lamp (if reduced to an equal surface) emits a light twelve times stronger than that of a slit-burner, and seven times stronger than that of an Argand burner (Renk). For determinations of the lustre. which are not quite simple, see Renk (*Arch. f. Hygiene*, iii.). Shades of matt glass easily admit of the prevention of dazzling. From the hygienic point of view the electric light is beyond question the best next to sunlight. The fluctuations in the intensity of the arc-light, which hitherto are scarcely avoidable, render it not perfectly suitable for the illumination of rooms in which any fine work has to be carried on.

V. Ventilation.

§ 449. In a previous section of this book it has been explained how the quantity of the exchange of air through the pores and crevices is determined (§ 117). The interchange of air in artificial ventilation is ascertained according to § 116. In artificial ventilation a determination of the volumes of air entering and escaping will not unfrequently show discrepancies, even if the observations are made as simultaneously as possible. Especially chimneys which draw well often carry away more air than enters through the ventilation channels; a considerable quantity of air penetrates through chinks, crevices, and pores. If calculations have to be made concerning ventilation, the larger of the values found by the two methods is to be regarded as correct.

If rooms are warmed by fresh air previously heated, its quantity will generally suffice for a renewal of the air. But if the warming is effected by means of hot bodies, an examination of the volume of fresh air which enters will be

necessary, as in the latter case the heating of the fresh air occasions special expense, and in consequence its quantity is often reduced too much from a mistaken economy.

The quality of the air which enters may be controlled by a determination of the carbonic acid, and by the thermometer and hygrometer; for the two latter determinations see Heating.

If we find a higher proportion of carbonic acid than in the open air (samples being taken by means of a long glass tube inserted in the aperture for the entrance of air), there is something wrong, in case of air-heating, either in the hot-chamber, or in the calorifer, or there is a reflux of air from the room into the channels, which is not uncommon in winter when school-rooms are energetically heated during the intervals between school-hours.

If the air entering is full of dust (not filtered), this is best detected by the deposition of dust in the heating-chamber, or on the heating bodies (in case of mechanical ventilation), or in the entrance channels. If at the same time the air is heated, or the calorifer is not air-tight, black stains near the air-inlets betray the presence of soot. The smell of soot and a sensation of dryness in the throat assist in the detection of smoke in the air. Not unfrequently this sensation is erroneously referred to an excessive dryness of the air.

We must never be content with the mere removal of air, since the air entering is often derived from localities where it is accompanied by offensive smells (kitchens, privies, &c.). In mechanical ventilation pressure is from the same reason always to be preferred to suction.

The inlet for warmed air is generally placed at the height of the human head; the exit for the air which has been used is twofold, one for winter at the level of the floor, and one for summer aloft, and capable of being opened or closed by valves. Anemometers and determinations of carbonic acid suffice to reply to the question whether one or the other exit is to be preferred at any given time. Abt (*Hyg. Rundschau*, i. 148) has discussed this question in an investigation

containing many interesting details. On ventilating valves at room-stoves see § 451.

In ventilation by mechanical appliances (wing-screws, water-jet ventilators), it must also be considered whether an annoying noise is not produced which is often conveyed to a distance in the ventilating pipes. (In water-jet ventilators this may be avoided by lining the pipe with felt near the rose.) We must also consider whether drops of water may be projected into the room along with the compressed air, and whether the air (generally not warmed) is not introduced in such compact streams as to annoy persons sitting near the inlet. If a valve is fixed obliquely before the apertures, compelling the air to enter laterally, complaints will rarely be occasioned.

For an adult in dwelling-rooms we generally require, as a minimum, 20 *cbm.* of air (for hospitals two or three times as much). More modern hospitals afford 100 *cbm.* space and upwards per bed, which deserves to be much appreciated. Three interchanges of air per hour are practicable without occasioning a draught (*i.e.*, a velocity of wind not exceeding 0.7 *m.*), but not more. A minimum of 60 *cbm.* of air is thus always available. A renewal of the air is not possible without occasioning the sensation of a draught if the velocity of the wind exceeds 0·7 *m.*

For schools about from 5 to 6 *cbm.* per child is a minimum. The proposed Imperial law demands for bedrooms for children under 10 years of age 5 *cbm.*, and for each elder person at least 10 *cbm.* Even if a sufficient supply of air is secured in some other manner, there must be at least 1 *sdm.* of window-surface for each child, and for each adult double the surface (Draught Imperial law).

VI. Heating.

§ 450. A description of the various heating systems with their advantages and disadvantages, especially from an economical point of view, is explained in the text-books on hygiene. The means to control the effect of a heating

installation are simple. Both for central and local heating the following must be undertaken:

1. The temperature must be determined in various parts of the room by thermometers, protected if needful by the interposition of boards against direct radiation. Such investigations throughout the house are particularly needful in central heating arrangements, since they often bring to light serious defects in the distribution of warmth, especially in defective heating with air-pipes.

2. Determination of atmospheric moisture according to § 119, and a decision according to § 151. Contrivances for moistening the air may be tested by observing their effects with the hygrometer. Too strong moistening may cause the masonry (which is colder than the air of the room) to be thoroughly moistened, and it must therefore be avoided at least as much as dry air.[1]

1. Stove Heating.

§ 451. In heating with stoves we must especially consider:

1. Testing the radiant heat of the stove with the blackened bulb thermometer (§ 104). Generally speaking, we wish to warm with radiant heat as little as possible. Metal stoves radiate more strongly because their surfaces are much more strongly heated. In order to reach conclusions comparative experiments should be made on different stoves which warm the room equally, using the same thermometer. (For the more accurate examination with the thermic battery see

[1] It would be utterly useless to describe the construction of English house-fires. They warm a room entirely by radiant heat, and are calculated to waste 90 per cent. of the heat generated by the combustion of the fuel. Hence they have become more and more objectionable as coal is rendered dearer in consequence of the exhaustion of the more superficial beds, the higher wages of the colliers, and the operations of the coal-merchants. They have the disadvantage of producing large quantities of dust, soot, and smoke, and of rendering different parts of a room very unequal in temperature. Many German authorities do not admit the alleged hygienic advantages of radiant heat (Dr. F. Fischer). The open fire-place ventilates the lower part of a room too strongly, but leaves the air in the upper part stagnant. This evil is the worse the lower the grate is placed.—*Editor.*

Rubner's *Lehrbuch der Hygiene*, p. 241.) The action of stove screens must be checked in the same manner.

2. The temperature of the surface of the stove may also be examined. For earthenware stoves it is sufficient to apply a thermometer to the stove, keeping it in its place with a pad of wadding and a card. For iron stoves alloys of known melting-points (§ 100).

It is hygienically useful to keep the temperature low, certainly not exceeding 100°; at higher temperatures the fine dust which deposits on the stove is consumed, and the pyrogenous products formed irritate the mucous membranes. At the same time there is the danger that children burn themselves.[1] A smooth surface and a good lining of fire-clay in the iron parts are important for preventing the ignition of dust, and for preventing excessive heat.

Examination as to length of time required to reach a desired temperature, or a certain rise of temperature. It is in such experiments necessary for the external temperatures to be alike.

3. Structure of the chimney. Examination whether the stoves "draw." Chimneys have a round or quadratic section in order to facilitate cleansing with brushes and balls. The diameter is, according to the size of the bricks, from 15 to 20 *cm.*, or for larger heating installations from 25 to 30 *cm.* Two or three stoves may vent into one chimney if they are otherwise properly constructed. The chimney should be carried vertically from the stove to the highest point of the roof (or of any loftier roofs adjoining), and should run in the inner—not outer—walls, in order to avoid, as far as possible, the influence of the varying external temperature, and of the wind. For the sake of cleanliness it is advantageous if the chimney runs below the stove down into the cellar, so that the soot can be removed both here and on the roof, or in the attics in the case of steep roofs. A slight inclination from the perpendicular is permissible; the angle of the incline must not exceed 30°, and the elbow should be carefully rounded off.

A chimney is tested for draught by lighting paper in it, or holding a burning match at the stove door; the paper should burn briskly without smoke, and the match should be blown out or flare strongly.

[1] This danger is naturally much greater with open fires. In Britain many children and women are thus burnt to death or seriously injured.—*Editor.*

As the column of air in the chimney is colder than the open air (height of summer, a warm day in winter after severe cold), it may be necessary, even in the best constructed chimneys, to burn first some paper in the stove. If a chimney seems blocked up with soot the chimneysweep should be consulted.

4. Stoves with very narrow exit-flues or pipes, and especially those without smoke-vents, should always be condemned, since they show that they are apt to contaminate the air strongly with carbonic acid, or possibly carbon monoxide.

This applies as well to the so-called carbonnatro stoves. They pollute the air abundantly with carbon monoxide; it applies also to all gas-stoves, such as are still frequently in use in bath-rooms, and often without an exit-pipe. Carbon monoxide is not here formed, but carbonic acid is produced up to from 2 to 3 per cent., and at the same time the proportion of oxygen is diminished by from 3 to 4 per cent. (see § 151). Severe fainting fits and direct danger to life may be occasioned (see Knorr, *Arch. f. Hygiene*, xi.). The nose readily detects smoke-gases; smoke contains 8 to 10 per cent. of carbonic acid.

5. *Stove Valve.*—Stove-valves of the old construction in the chimney which at a given moment allow the latter to be entirely shut off, should be legally prohibited as quite anti-sanitary. If they are so constructed that not more than three-quarters of the section can be shut off there is little objection to be made, as the danger of poisoning with carbon monoxide seems removed.

The desired object is not entirely gained by the use of screwed stove-doors in place of valves, especially in case of tile-stoves, as the air of the room penetrates into the interior of the stove through joints and chinks, and thence into the chimney, which is rather rapidly cooled. Especially in self-replenishing stoves the degree of accuracy with which the degree of combustion may be governed by regulating the supply of air requires examination. An inspection of the colour of the fire through windows of mica is generally sufficient in a dark room.

It is easy to ascertain whether a so-called Degenklob

ventilation-trap acts. This apparatus is a throttle-valve, which closes a short ventilation-tube opening downwards where the smoke-flue makes an upward elbow. When the fire is burning brightly its supply of air is partially closed, and the throttle-valve is opened. A measurement with the anemometer determines the effect of this excellent ventilating arrangement.

6. I must refer to technical treatises for the question what stoves best fulfil their purpose. In general, small stoves with short pipes utilise the heat imperfectly. An increase of the surface by means of ribs and open spaces surrounded by flues is practical. (The large stoves which are still customary in isolated places, and in Berlin, utilise the heat much better.) It is more advantageous to feed several stoves, placed side by side or one above another, from one fire-place. The hearth may serve as fire-place (a throttle-valve which in summer cuts off the heating-gases from the way to the stoves, and which at the same time opens a direct passage to the chimney, should then be provided). In other cases the fire-place is preferably served from the entrance-hall, whereby dust, ashes, and dirt are kept at a distance from the dwelling-rooms.

2. Central Heating Installations.

§ 452. The complicated technical examinations of such arrangements do not fall within the plan of this work. The skilled hygienist can, however, very well determine the effect of such heating by means of the thermometer, hygrometer, and, if needed, the anemometer (see § 450); special apparatus are not needed.

In all varieties of heating by means of air, simple or compound (fire-, water-, steam-, steam and water-, air-heating) the temperature of the heated air must not exceed 40°, or at the outside 60°. This may be attained by placing ribs or steam-pipes on the calorifers, or by leading such pipes through wide water-mains.

Among central-heating arrangements those with hot air give principally cause for complaint, because formerly they were often constructed in a negligent manner. I discuss them, therefore, thoroughly, and add merely a few remarks on the other systems of heating.

1. The inlet-channel for air into the heating-chamber should

be open to inspection, having smooth sides, should be easily cleansed, and should be actually clean. When this is not the case the deposit of dust as a bad conductor may easily interfere with the utility of heating. At high temperatures the dust burns away (§ 449). Heating-chambers should be lighted up by windows, whitewashed, completely enclosed. The calorifers should be kept so clean that no soot can enter the chamber. (The doors for cleaning open outwards.)

2. The calorifers should be large so that they need not be heated too strongly, and they should be lined with clay as far as the flame reaches. The combustion of dust can be effected only by this means. The air in the heating-chamber should not be hotter than from 80 to 100°. Thermometers must be provided. A good automatic regulation of the fire, as has been recently aimed at (Rietschel and Henneberg), greatly improves the system.

3. The air must be freed from dust by filtering-cloth and a "water-veil" (fine artificial rain). For an examination of filtering tissues see Rietschel, *Gesundheits Ingenieur*, 1889, p. 106. The filter-cloths must be brushed every fourteen days.

4. There should be an arrangement for the evaporation of *clean* water in the heating-chamber, which is automatically supplied in the evaporation-vessels.

5. Complaints about the distribution of temperature in hot-air arrangements in the various stories of a house, or in the different rooms of a tenement, should lead to an examination whether the hot-air pipes in the upper stories are suitably narrower than in the lower, and if the rooms which lie horizontally from the source of heat are provided with pipes of a sufficient width. But even in case of correct dimensions of the pipes an unbearable heat may be produced in the upper stories if the valves in the lower stories are closed as soon as the inmates consider their rooms sufficiently warm.

In heating with hot water care must be taken that the pipes are free from dust, and secure against frost. They should be easily accessible, and be yearly submitted to a thorough cleansing before being used for heating. In case

of constant use freezing is not to be feared; where the use is intermittent serious trouble is often occasioned by overflows into dwelling-rooms. That hot-water heating at high pressure can be arranged only with correspondingly strong and faultless pipes, and is better avoided in place of a safer heating with warm water, is a matter of course.

In heating with steam-pipes inclosed portions of water are to be avoided, as they occasion much annoyance by keeping up a hammering noise. Accumulations of air in portions of the piping which have been temporarily left out of use are to be feared. This misfortune is most common in low-pressure steam systems, and it greatly interferes with the efficacy of the system, especially when its management is left to servants. The manner of construction should exclude all such disturbances. Arrangements affected with such faults should not be accepted.

The introduction of the stand-pipe and the expansion vessel in low-pressure steam heating require caution, since if the pressure of 1·5 atmosphere is exceeded, boiling water may be projected out.

In low-pressure steam-heating the encased pipes require especial examination, *i.e.*, whether the casing does not in fact completely prevent the emission of heat from the pipes, &c. Thermometric measurements allow a decision on this head.

VII. Water-Supply.

§ 453. In addition to the points explained in the section on "Water," we must add:

1. *The Examination of House-Cisterns, if any.*—They should consist of sheet-iron coated with enamel colours free from lead, but not of lead, tin, or zinc. Lead is inadmissible even where leaden pipes may be used (see § 201, 6), as in a cistern the access of air is always promoted. An inspection of the cistern often reveals impurities: entrance of dust in consequence of defective adjustment and covering, development of dense flocculent masses of bacteria, larvæ of aquatic insects, &c.

The overflow-pipes of cisterns should not open into the soil-pipe of a W.C. without the intervention of a syphon.

2. Examination of the security of the water-pipes—especially narrow branch-pipes—against frost.

Water-pipes should not lie against the outer walls, or if placed there they should be surrounded with a heat preservative mass (asbestos, cork, slag-wool, kiesel-guhr, &c.). Such a coating is also necessary in rooms which are rarely heated (W.C., bath). The main inflow and outflow pipes should lie at least from 0·8 to 1·00 *m.* below the earth in order to remain at a uniform temperature.[1]

VIII. Removal of Foul Water (House Sewerage).

§ 454. In an examination it must first be ascertained whether the foul waters from the house fall into a sewer or into a settling-pit. In houses which stand alone the latter is the only possible method if no discharge into a stream is possible; but it is at least requisite that the settling-pit should be sufficiently far from the house.

In the course of the foul water to the settling-pit, it is advisable to arrange one or two small well-cemented pits as clarifying tanks, so that the water in the settling-pit is clear enough to be used for watering vegetables. These clarifying tanks should be easily cleansed.

The water-pipes in the house must fit tightly; they must never be of stoneware with tarred joints but of iron with lead joints; and where they are connected with inlets, water-joints must be used. In new buildings the syphon is often omitted, especially in baths, wash-houses, &c., owing to the negligence of the persons executing the work. The water-joints are generally pipes bent in the shape of a U. More complicated joints are often used in kitchen drain-pipes. If the present joints act badly, so that sewer-gases

[1] It need scarcely be added that cisterns are to be condemned from a sanitary point of view. In practice they are never made dust-proof. In those cities in Britain where the water-supply is in the hands of the municipality, cisterns are as a rule absent, and water can be obtained from the pipes at any moment.—*Editor.*

may penetrate into dwellings, it is necessary to ascertain if one of the following main errors does not occur (Renk):—

1. The soil-pipe does not vent freely above the roof. It is desirable that both the kitchen drain-pipe and the exit-pipe from the W. C. should pass above the roof.

2. The soil-pipe is too narrow in proportion to the outflow-pipes.

3. The pipes leading down from the gratings of the sinks, or from their syphons, are abnormally wide, so that on abundant pouring, emptying jugs of water, &c., even a wide exit-pipe runs full, and the syphon concerned, or those lying above it, are emptied or much weakened, while those below are overpowered.

4. The joints are so badly constructed that the column of water which forms the junction is only a few millimetres high; and if there is any inaccuracy in the fitting of the joint it is altogether useless. Such a joint also very quickly fails if it is allowed to stand for a time unused in hot weather (evaporation of the water).

5. More complicated joints, instead of having a narrow peripheric and a wide central limb, are often in error constructed in the inverse manner, so that any action weakens the joint to a great degree. It must be accepted as a principle that the pipe for the escape of foul water must always be expanded from the grate of the sink to the house sewer, but never contracted.

The very slight over-pressure of the sewer air over the air of the room—positive or negative—is never able to break through a water-joint of a few centimetres in height. All overpowering or exhaustion of water-joints is due merely to condensations or expansions of air which occur in the soil-pipe by the abundant influx of water, if the enclosed air cannot communicate with the external air without hindrance or interruption from any of the defects enumerated under 1–4.

6. The arrangement is indeed properly constructed, but has been carried out imperfectly (bad cementing, soldering of the several pieces of pipe), or it may have become defective (iron pipes may have been corroded by rust, tubes of

zinc or lead may have been attacked by sewage in conjunction with sewage gases, or of moist mortar or cement; leaden pipes may have been gnawed by rats or by the larvæ of solitary wasps, rupture of the pipes by frost, &c.).

7. Lastly, putrid odours are not necessarily occasioned by sewage gases, in the strict sense of the term; syphons filled with putrescent matter, floors or false flooring impregnated with filth, may sometimes simulate the entrance of sewage gases. As to the hygienic importance of sewage gases see the next paragraph.

In an inquiry at what point sewage gases escape the nose plays the most important part, if the leak is not large enough to be at once visible. The deflection of the flame of a candle, or the production of soap-bubbles after the suspected part has been coated over with thick soap-froth, are important means of detection. In kitchen sinks the examination is best undertaken after dinner, as then the outfall pipes are slightly warmed by the passage of the slops, and sewer-gases will be evolved plentifully. Strongly-scented ethereal oils (oil of aniseed, &c.) have been poured into the pits or house drains in order to give a definite odour to the escaping sewer-gases.

IX. Closets.

§ 455. Every closet must have a window leading into the open air; the soil-pipe must be prolonged above the roof, and have a free opening above. If the water-supply and the water-joints are good a ventilation from the staircase or by air-shafts may suffice.

If water is not laid on in the closet, the soil-pipe of each seat cannot be shut off from the main-pipe by a syphon, as the contents of such a syphon (fæces and urine) would pollute the air at least as strongly as any sewage gases which might enter. The outfall of the fæcal matters should be facilitated by causing the lateral soil-pipes to vent into the main-pipe at an acute angle, and an escape of sewage gas is to be prevented by a valve which generally closes the

funnel of the basin, or, better still, by heating or exhausting the main soil-pipe; narrow soil-pipes easily become choked, and sometimes freeze up in winter.

The soil-pipe is most cheaply heated by placing it next the kitchen chimney. A branch from the soil-pipe may be carried into the upper or lower part of such chimneys, or into an adjacent fume-pipe. A ventilation of the closet, in the absence of water-joints, is very dangerous; if the sewer-gases are warmer than the external air they escape into the closet, and that the more readily the easier is the outlet through the open window. On the other hand, a close connection of the soil-pipe to the removal-pail, or the cesspool, greatly impedes the escape of sewage gases (Von Pettenkofer).[1]

We may ascertain by means of a benzoic acid match whether sewage gas escapes from the seat; the anemometer (§ 114), if held in the opening of the closet-funnel, gives a quantitative estimation of the movement of the air (§ 116). The water-tightness of the soil-pipe can often be ascertained only by removing its wooden casing. The water-tightness of a tub[2] is found by inspecting its place. To determine the water-tightness of cesspools is difficult. Even well-cemented cesspools are not absolutely impervious for a long time; the more rarely a pool of moderate size is filled and emptied, the more pervious and the more dangerous it becomes. An examination of the soil around the cesspool for NaCl, &c., permits a definite conclusion. Depositing tanks for fæcal matter are absolutely inadmissible.

§ 456. In water-closets simple flat U-shaped syphons are effective against sewage gases. The effectiveness of the water influx must be controlled experimentally. Closets in which the fæces fall into water facilitate rinsing away, as the excrementitious matter does not adhere, and thus economise water, but cause annoyance during defæcation by splashing. Weak rotating currents of water which fall into wide, dish-

[1] This passage refers only to towns where the "pail system" or the old cesspool arrangement is still in vogue. In most British towns the soil-pipes vent into the public sewers. Cesspools are tolerated only in country places.—*Editor.*

[2] Again a reference to the pail system.—*Editor.*

shaped basins are unpractical; they often merely drive the fæces round in a circle.

If there is abundance of water at a considerable pressure at disposal, it may be taken directly from the pipes to rinse out the basin, simply turning a cock. Against this arrangement there are no hygienic objections, though prejudices often prevail. If the water-supply is obtained from cisterns they must be fixed sufficiently high, and must be of adequate capacity to effect a proper action.

The fearful smell often met with from water-closets, apparently well constructed, often becomes intelligible if we remove the wooden casing of the pan. There appear then imperfect joints, and infiltrations of polluted water into the non-ventilated corners between the seat and the casing. On several occasions I could detect merely an imperfect connection of the water-pipe with the rinsing arrangement as the cause of the mouldy smell; a flexible pipe connected both, and had been secured with a brass wire, which was corroded away, and now allowed an escape whenever the water was turned on.

I cannot enlarge more fully on the construction of house and street sewers. They can be examined as to their imperviousness or water-tightness only by laying them bare—especially the stratum of earth underneath the sewer, and its chemical examination (§ 156). Whether their incline is sufficient must be ascertained by examining the sewage matters which accumulate in them in course of time. A "revision-shaft," which is officially required in many cities at the spot where the house-sewer vents into the street or court-sewer, greatly facilitates an examination.

For a formal decision concerning an entire sewerage system there are, above all things, required, in addition to technical knowledge and practical experience, a most accurate acquaintance with local circumstances, the incline of the ground, the rainfall, the existence of brooks for rinsing, &c. Especial methods of examination are scarcely requisite.

It is very important here for the sections of the sewers to be duly proportioned, so that always narrow sewers may open into wider ones, and not inversely, and that the bottoms of the drains are narrow and smooth. These essentials have often been neglected in old sewerage systems.

The danger to health of sewage gas is estimated extremely high in England. In numerous instances attacks of typhoid

fever are especially attributed to the respiration of sewage gases. In Germany Uffelman adopts to some extent the English point of view, whilst Pettenkofer, Soyka, and Renk maintain that the toxicity of sewage gases has not been hitherto demonstrated by the illness of the inhabitants of sewered houses.

A circumspect hygienist must unconditionally admit the possibility of an injurious action of certain septic gases in a concentrated state, although hitherto no especially poisonous gases are known except sulphuretted hydrogen and ammonia. Interesting experiments have been made by Herbert Barker (*Sanitary Review*, 1158) on dogs, birds, and mice concerning the action of sewages gases and the air of cesspools. He observed in these animals, shut up in chests traversed by the air in question, faintness, trembling, loss of appetite, vomiting, and diarrhœa. According to special experiments with sulphuretted hydrogen, he is disposed to attribute the chief result in the experiments to the effects of this gas. Unfortunately he has contented himself with qualitative analyses of the air in the chests (H_2S, NH_4S, CO_2). Odoriferous substances, as yet imperfectly known, may easily play a part in the poisonings. Literature certainly contains somewhat numerous reports of illness occasioned by inhaling the perfume of flowers (see Chevallier fils, *Annal. d'Hygiene*, 1865, p. 293). Vallin reports cases which he regards as poisoning by the use of putrid, stinking paste in putting up paper-hangings, or by washing walls with a putrescent glue colour (*Annal. d'Hygiene*, 1880, p. 50). Still an infection of typhoid [1] in this manner will always appear to us incomprehensible, since sewage air is always poor in micro-organisms, or free from them entirely, and as the men employed in sewers are nowhere especially liable to infectious diseases.

Decidedly more dangerous are sewers, settling-pits, &c., which are not air-tight, as they occasion the soil to be saturated with nutriment for micro-organisms.

It is clear that incautious manipulation of relatively recent fæcal matter on the part of scavengers (want of cleanliness)

[1] The bacilli of typhoid (*Centralblatt f. Bakteriologie*, v. p. 530) persist, according to Uffelmann, at least 5½ months at 17°; the bacilli of cholera were mostly reduced in number after twenty-four hours, and destroyed often after forty-eight hours, but always after three to four days. This was also observed by Kitasato and Kaupe, whilst Gruber discovered cholera bacilli in the dejections of cholera patients after fifteen days, and Karlinski after twenty-five days. Schiller (*Arb. aus dem Kaiserl. Gesundheitsamt*, vi. 1890) found cholera bacilli still living in sewage, and in a mixture of fresh urine and fæces for thirteen to fourteen days; typhoid bacilli six days in sewage, and from one to four weeks in a mixture of urine and fæces.

may occasion infections; but there are cases, such as those described by Ducamp (*Centralblatt f. Bakteriologie*, viii. 404), which are very difficult to explain. Six workmen at Montpellier, who drew out a disgustingly stinking vessel from a choked-up drain, were all taken ill with different intensities—partially with the incubation stage—of a gastric nervous affection, complicated with tetanus. Intestinal symptoms and typhus fever were absent. What gas can the vessel have given off?

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The following weekly English journals, all published in London, treat to a considerable extent on the hygiene of buildings :—

Mechanical World.
Mining Journal.
Machinery.
Engineer.
Iron Trades.
English Mechanic.
Timber News.
Engineering.
Timber Trades Journal.
Gas World.

SECTION XVIII.

ARTICLES OF USE, OR HOUSEHOLD APPLIANCES.

§ 457. As articles of use we characterise all those substances which play a certain part in the household, whether in connection with food (cooking utensils, wrapping-papers) or with dwellings (carpets, curtains, lamp-screens) or clothing (tissues, paper-collars, flowers, &c.), or come otherwise in more or less intimate contact with mankind in daily use (address-cards, toys, quack medicines, requisites for the toilet, &c.).

The hygienist has to examine these articles for a great number of injurious substances, inorganic and organic, especially poisonous metallic salts and poisonous colours. It seemed, therefore, judicious to reserve to this section whatever might have been said in earlier chapters on the detection of and the decision on such substances, and to enlarge this section to a condensed chemistry of the most important poisons, or to a toxicology of the most important substances in the household.

Here it was necessary, if the compass of the book should not be exceeded, to observe a careful limitation to questions, the solution of which might be successfully undertaken by less experienced operators, and to substances to which (rightly or wrongly) an especial hygienic importance is at present ascribed.

As a matter of course substances which only occasionally —from grave negligence—lead to poisoning cases (lye, sulphuric acid, petroleum, phenol, &c.), will not be here taken into consideration. For the sake of convenience we consider the examination of and the decision on inorganic and organic substances separately.

§ 458. As an introduction we here communicate the two German statutes on this subject, since they are founded upon careful consideration of the demands of hygiene and of technics, and may be regarded as happy compromises.

STATUTE CONCERNING THE TRAFFIC IN ARTICLES CONTAINING LEAD AND ZINC.—*June* 25, 1887.

§ 1. Implements for eating, drinking, and cooking, and measures for cooking may not be made—

1. Entirely or partly of lead, or of a metallic alloy containing more than 10 per cent. by weight of lead.
2. May not be coated inwardly with a metallic alloy containing more than 1 per cent. by weight of lead, or be soldered with a metallic alloy which contains more than 10 parts of lead in 100 parts of the alloy.
3. May not be provided with enamel or glazing which, if boiled for thirty minutes in vinegar containing 4 per cent. by weight of acetic acid, gives off lead to the solvent.

The prescription under figure 2 concerning solder does not extend to table-ware or measures for liquids made of Britannia metal free from lead.

For the construction of so-called beer-engines, and for syphons for beverages charged with carbonic acid, for the metallic parts of sucking-bottles for infants, only such alloys may be used as contain in 100 parts not more than 1 per cent. by weight of lead.

§ 2. For the construction of mouth-pieces for sucking-bottles, sucking-rings, and shields for corns, caoutchouc containing lead or zinc may not be used.

Plumbiferous caoutchouc may not be used for drinking-cups and for toys, with the exception of massive balls.

Flexible piping made of plumbiferous caoutchouc may not be used for beer, wine, or vinegar.

§ 3. Vessels and appliances for the preparation of beverages and fruit-juices may not be constructed contrary to the directions of § 1 in those parts which in their intended or probable use come in immediate contact with the contents.

Boxes for preserved meats or fruits must be made on the inside in conformity with the conditions of § 1.

For keeping beverages, vessels must not be used in which there are remnants of leaden shot. For enveloping snuff and chewing-tobacco, as also cheese, metal-foil must not be used containing more than 1 per cent. by weight of lead.

The fourth paragraphs relate to penalties, &c. The law came into force on October 1, 1888.

STATUTE CONCERNING THE USE OF INJURIOUS COLOURS IN THE PREPARATION OF FOODS, ARTICLES OF CONSUMPTION, AND OBJECTS OF UTILITY.—*July* 5, 1887.

§ 1. 1. Colours injurious to health may not be used in the production of articles of food or enjoyment, if intended for sale.

2. Injurious colours in the meaning of this law are those colouring-matters and preparations of colours which contain antimony, arsenic, barium, cadmium, chrome, copper, coralline, gamboge, lead, mercury, picric acid, tin, uranium, zinc. The Imperial Chancellor is empowered to issue detailed directions concerning the methods to be adopted in determining the presence of arsenic and tin.

§ 2. 1. For preserving or packing up articles of food or enjoyment which are intended for sale, vessels, wrappings, and covers may not be used if in their manufacture colours of the kind specified in § 1, section 2, have been employed.

2. This determination does not extend to the use of barium sulphate, chromic oxide, copper, tin, zinc, and their alloys as metallic colours, cinnabar, stannic oxide, tin sulphide, as mosaic gold, as also all colours burnt in upon vitrified masses, glazes, and enamels, and also the outer coating of vessels of waterproof materials.

§ 3. For the production of cosmetics (articles for cleansing, preserving, or colouring the skin, the hair, or the inside of the mouth) intended for sale, the substances mentioned in § 1, section 2, must not be used. This regulation does not apply to barium sulphate (heavy spar, blanc fixe), cadmium sulphide, chromic oxide, cinnabar, zinc oxide, tin oxide, zinc sulphide, or to copper, tin, or zinc in the state of powders.

§ 4. 1. Those colours specified under § 1, section 2, must not be used in the manufacture of toys, including sheets or books of pictures, and water-colours for children), frame-work for flower-pots, and artificial Christmas-trees.

2. This regulation does not apply to the substances mentioned in § 2, section 2, as also to antimony sulphide and cadmium sulphide as colouring-matters for gum mass, lead oxide in varnish, white lead as an ingredient in so-called wax-casting, but only if it does not exceed 1 part by weight in 100 parts by weight of the mass, lead chromate (alone or in combination with lead sulphate) as an oil or lake colour, or with a coating of varnish or lacquer, compounds of zinc insoluble in water, but in case of caoutchouc toys, only in so far as they are used to colour the caoutchouc mass, as oil or lake colours, or with a coating of lacquer or varnish, and all colours burnt in, as glazes or enamels. As far as the substances mentioned in §§ 7 and 8 are used in the manufacture of toys, the regulations laid down in §§ 7 and 8 apply simply to the latter.

§ 5. For the production of letterpress and lithographic printing upon the articles enumerated in §§ 2, 3, and 4, only those colours are prohibited which contain arsenic.

§ 6. Water-colours of every kind may not be sold or offered for sale as free from unwholesome or poisonous matters if they do not conform to the regulations in § 4, sections 1 and 2.

§ 7. In the manufacture of paper-hangings, furniture-prints, carpets, tissues for curtains or hangings, masks, candles, artificial leaves, flowers, and fruits, colours which contain arsenic may not be used. But this regulation does not apply to the application of arsenical mordants and fixing agents for the purpose of dyeing or printing warps or tissues. But such warps and tissues may not be used in the production of the articles specified in section 1 if they contain the arsenic in a form soluble in water, or in such a proportion that more than 2 *mgrm.* arsenic are present in 100 *scm.* of the product when finished. The Imperial Chancellor is empowered to issue detailed instructions as to the means to be adopted for determining the proportion of arsenic.

§ 8. The regulations in No. 7 apply also to the manufacture of writing-materials intended for sale, lamps and light-screens, &c. The production of wafers is subject to the regulations in § 1, though with the proviso that, if they are not intended to be eaten, the use of barium sulphate (heavy spar, blanc fixe), chromic oxide, and vermilion is permitted.

§ 9. Arsenical water- or size-colours may not be employed for the preparation of washes for floors, ceilings, walls, doors, windows of dwelling- or work-rooms, for shutters or curtains, furniture, and other articles of domestic use.

§ 10. The regulations of §§ 2–9 do not apply to the use of colours which contain the substances scheduled in § 1, section 2, not as constituent ingredients, but merely as impurities, and at most in quantities unavoidable according to the methods of production technically in use.

§§ 11–15 contain penalties. The law came into force May 1, 1888.

§ 459. Whilst the law of the empire lays down a limit of admissibility only for arsenic, Prior and R. Kayser have proposed the following limits for other elements, seeking as far as possible to take practical relations into account. The Bavarian chemists had adopted these figures, but the law of the empire considers it better to trust to the experience of experts, rather than to fetter their freedom of judgment by limit-numbers. These limits, however, seem to me very useful for the guidance of less experienced hygienists, as they agree fairly well with sanitary requirements.

There may be sanctioned as impurities in 100 *grm.* of the permitted colours the following quantities of those which are prohibited :—

a. Antimony, arsenic, chrome, copper, lead, together or of each, 0·2 *grm.*

b. Barium, cobalt, nickel, tin, uranium,[1] zinc, jointly or of each, 1·0 *grm.*

In general, according to Prior, 1 *grm.* of an opaque colour is needed for 100 *scm.* of painted wood, or 600 *scm.* of coloured paper or paper-hangings.

Lastly, the Bavarian chemists plead for the sanction of as much as 12 per cent. zinc chromate in green mixed colours (zinc-green, § 490) for coloured papers, artificial flowers, and paper-hangings, and as much as 3 per cent. of barium carbonate in coloured lakes. For antimony in yarns and tissues they propose the same strict limits as the Imperial law does for arsenic.

I. *INORGANIC SUBSTANCES.*

A. Examination for Inorganic Substances.[2]

1. Obtaining the Material for Examination in a Form suitable for Analysis.

§ 460. As the operations to be described below are generally to lead not only to qualitative but also to quantitative results, it is often necessary to set out with a weighed quantity, and to avoid every loss in working. The material must undergo very different kinds of treatment in order to be fit for analysis.

1. Metal vessels, metal coatings, metal foil for packages, &c.[3] We weigh off from ½ *grm.* to 1 *grm.* in the form of

[1] According to Kobert and Woroschilsky, uranium is equal to arsenic in toxicity, and should therefore be placed in class *a*. See *Arbeit. des Pharmak. Instit. zu Dorpat.*, Part V., 1890.

[2] What is here said does not refer to *free yellow phosphorus*. For its detection the matter in question is distilled in an apparatus similar to that in Fig. 84, but with an upright condenser. Into the flask *a* standing in the water-bath is put the substance in question, ground up with water to a thin paste, and acidulated with sulphuric acid. From the flask *b* there is passed a powerful current of steam through *a* and the condenser. Then when the steam condenses in the cooler there appears, if the room is darkened, a splendid phosphorescent ring. Small fractions of a milligramme give this reaction. The distillate in *d* gives the reaction of phosphoric acid *only* if free phosphoric acid was present, which is tested for according to § 185.

[3] In order to test the thickness of silvering or nickelising, we place a measured piece of the metal in dilute nitric acid until fresh acid ceases to dissolve any more of the metal required, and proceed then according to the systematic process (§ 462).

If the more exact nature or the purity of the layer of tin on sheet-iron has

fine particles, detached from the substance with a pen-knife, scissors, or a glass file, and dissolve by boiling in dilute nitric acid, to which hydrochloric acid may be added if a white powder (metastannic acid, SnO_3H_2) remains undissolved. We may, however, at once collect the metastannic acid upon a filter for analysis (§ 481).

The solution obtained is evaporated down as far as possible, to expel excess of acid, and is then diluted with water. In this manner we examine for copper, zinc, and lead, or also for iron and nickel.

2. Enamelled or glazed vessels are nearly filled with acetic acid at 4 per cent., and the contents are boiled for half an hour; the liquid is then concentrated in a vessel free from lead, filtered if requisite, and treated with a current of sulphuretted hydrogen.

In general we test merely for lead, which is shown according to § 467. A precipitate formed consists of lead sulphide.

Filsinger asserts that in almost all enamels he has obtained a stanniferous solution on digestion for from six to eight hours in the cold with hydrochloric acid at 1 per cent. (detection according to § 474).

3. In the examination of water we simply evaporate 1 litre or several litres of water down to about 200 *cc.* (§ 197), with the addition of a little nitric acid. But in case of waters rich in organic matters, incineration is necessary, possibly with the addition of a little saltpetre.

§ 461. If the inorganic substances to be sought for are mixed with an abundance of organic matter, *e.g.*, in clothing, paper, paper-hangings, toys, articles of food, &c., a mechanical separation may be first attempted. Thus layers of

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to be examined, we heat weighed pieces of the metal in dilute nitric acid as long as stannic acid is deposited. When this is effected the pieces are removed from the capsule and the contents are examined for tin and lead. The proportion of the two results enables the quantity of lead in the tin to be determined. Examinations of the solder with which tins are closed up is troublesome, as very little material is available. The only resource is careful scraping off with a knife. These investigations are important, since solder containing much lead is often used even when the cans are tinned with the finest tin.

colour may be scraped off from a measured surface, and thus the working up of the organic matter may be to a great degree obviated. The further separation of organic and inorganic substances is then effected—

a. By preparing extracts with water, acids, or alkalies, which, however, is chiefly advisable only in a preliminary search for certain substances, and should be omitted by beginners, unless there is abundance of material. But for a decision it is often very important to know whether elements are present in a soluble or an insoluble form; *e.g.*, in the examination of textile fabrics for antimony and arsenic, as also in the search for barium, it must never be omitted to ascertain whether the poisons are soluble in water or dilute hydrochloric acid.

The more experienced operator will often be able to obviate the more circumstantial methods *b* and *c* by a judicious selection and combination of solvents.

b. By destroying the organic substance.

1. According to the principles laid down in § 210, the substance is burnt to ashes in a porcelain capsule. But antimony and arsenic may thus escape, at least in part, and also copper, mercury, and zinc may be partly volatilised by conversion into chlorides in presence of much sodium chloride. In order to avoid this loss the dried organic substance should be moistened with concentrated sulphuric acid *before* incineration, as copper and zinc sulphates are certainly not volatile. This method is very certain for all heavy metals except mercury, though the incineration is rendered more tedious.

2. The organic substance, dried and finely powdered, or cut up extremely finely (from 1 to 10 *grm.*), is introduced in small portions into a capacious crucible containing melting saltpetre in excess (*i.e.*, so much that the melt always remains of a pale colour). This method is much to be recommended for articles of caoutchouc, and indeed for all the heavy metals except mercury. Even arsenic is not volatilised. Copper oxide is sometimes separated out as a grey turbidity, but almost all other substances are converted into com-

pounds soluble in water. Insoluble residues are: ferric oxide, lead sulphate, silicates, barium sulphate, and possibly silver chloride. In many cases it is practicable to use instead of saltpetre nitric acid, with which the substance is evaporated down in a porcelain capsule upon an asbestos plate. When the liquid is almost expelled there suddenly takes place a rather violent oxidation of the mass, sometimes attended with slight phenomena of combustion. By subsequent repeated additions of small quantities of nitric acid we obtain a very rapid and convenient mineralisation. With copper, *e.g.*, this method gives very good results.

3. According to Fresenius and Von Babo we destroy the organic matter by means of nascent chlorine. Available for the determination of all metals, as well as arsenic, antimony, &c. The method is especially applicable to foods, animal organs, portions of dead bodies, &c. Liquids, beer, wine, &c., previously evaporated down to the consistence of a syrup (with an addition of soda), may be treated in this manner. Every trace of alcohol must be previously expelled. The substance, comminuted as finely as possible, is stirred up to a thick paste with much pure (free from arsenic) hydrochloric acid. About 3 *grm.* potassium chlorate are added. The whole is then transferred to a roomy flask, which is closed with a caoutchouc stopper having two perforations. Through the one there passes a tube-funnel, cut off short, fitted with a cock, and filled with a saturated solution of potassium chlorate. Through the other enters an ascending-tube cut off below the stopper. The flask is allowed first to stand for about one hour at the temperature of the room, and is then heated upon an asbestos plate, very cautiously at first, but afterwards more boldly. After some time the solution of potassium chlorate is allowed to fall in drop by drop by opening the cock.

The development of chlorine must be continuous, but never so strong that the gas above the level of the liquid shows a distinct yellowish-green colour. After a time it may become needful to add repeatedly more hydrochloric acid, but ultimately the liquid becomes pale yellow or yellowish-

brown, and only fats and derivatives of fats are suspended in it, and a few unchanged mineral constituents. After the funnel-cock has been replaced by a long elbow-tube, the dissolved chlorine is expelled by a current of washed carbonic acid, and the liquid, which has lost the smell of chlorine, is filtered.

A complete destruction of the organic substances, as it is required for any exact examination for metals, can be obtained by this method only with great difficulty, so that it can be recommended only when the other processes are inapplicable on account of volatilisation.

There remain upon the filter, the contents of which must be repeatedly boiled out with water, along with fats, and possibly cellulose: barium and lead sulphates (white), cinnabar (red), chromic oxide (green), silver chloride (white, but turning to a violet in light). Of these substances, chromic oxide and cinnabar, which were present in an insoluble state in the original material, have no hygienic interest. On the other hand, lead sulphate, barium sulphate, and silver chloride may have been formed from soluble compounds during the destruction of the organic substances. Sulphuric acid may be formed from the sulphur of the albumenoid substances and the sulphides. The filter with the residues from chlorination is burnt in a crucible. Lead sulphate is detected according to § 467; barium sulphate and silicates as in § 327, and silver chloride as in § 465.

2. Systematic Separation and Detection of the most Important Elements.

§ 462. The aqueous solution of the saltpetre melt, and also the solution in chlorine and hydrochloric acid, contains, with the few exceptions enumerated in the foregoing section, the elements which are hygienically important in their entirety:

Antimony	Chrome	Mercury
Arsenic	Cobalt	Tin
Barium	Copper	Uranium
Bismuth	Lead	Zinc
Cadmium	Nickel	

We must not omit in our considerations silver and iron; silver because it may easily occur in our analyses in various alloys, and still more as a coating on metals of inferior value.

Iron is found in most every substance which has to be analysed; manganese, as a constituent of the ash of many plants, must also be mentioned.

We shall first give a short methodic process[1] for the detection and separation of the several elements enumerated above, a procedure which the beginner must always follow if the question is not merely the recognition of a given element; in this latter case Chapter III. (§ 467) will often greatly simplify the operation. The separation, according to the indications of these schemes, is quantitatively accurate; if such a determination is required the elements, after separation, can be converted into the most convenient form, according to Chapter IV., § 481.

SCHEME I.

§ 463. If the solution contains no hydrochloric acid, a little is added, when silver is precipitated, as AgCl (see § 465). Any lead chloride which accompanies the silver chloride may be removed by means of boiling water, when the plumbiferous solution is added to the filtrate. A precipitation of mercury as mercurous chloride need not be feared, on account of the previous treatment with chlorine (simple incineration and fusion with saltpetre are inadmissible in case of mercury; see § 461).

SCHEME II.

§ 464. We pass into the hydrochloric solution a current of sulphuretted hydrogen free from arsenic (§ 471) from a Kipp apparatus, shaking repeatedly, and continuing this treatment for thirty minutes to four hours. For shorter experiments we may use instead of a Kipp apparatus a simple flask with a cork having two perforations. Through the one aperture there passes a long vertical tube which plunges into the liquid, and the other a short gas-delivery tube. If the precipitation is supposed to be completed, we allow the beaker containing the precipitate to remain for a time covered, and try if it has still a strong smell of sulphuretted hydrogen. If the odour has disappeared, the introduction of the gas must be continued.

There are thus deposited arsenic, antimony, tin, mercury, lead, silver, bismuth, copper, and cadmium as sulphides, which may be separated after filtering and washing with hot distilled water. The

[1] For the following schemes, as well as the special reactions, the judicious work of Arnold (*Kurze Anleitung zur qualitativen Chemischen Analyse*, 3rd edit., Hanover, 1890) has been largely taken as a foundation (in some parts *verbatim*).

filtrates and washings are poured together, and examined further according to Scheme III.

The filter with the precipitated sulphides is placed in a capsule and heated with yellow ammonium sulphide; filtered after a few minutes, the extraction is repeated, and the liquids thus obtained are poured together.

A. The solution in ammonium sulphide contains arsenic, antimony, tin, and traces of copper in the form of sulpho-salts (*e.g.*, ammonium sulpharseniate $AsS_4(NH_4)_3$).

It is evaporated to dryness, the dry residue is again evaporated to dryness with small portions of fuming nitric acid cautiously added until it becomes a light yellow, and a further addition of acid liberates no more red fumes. A few drops of pure soda-lye are added, the whole is ground up with a dry mixture of sodium carbonate and sodium nitrate (1 : 2), and the saline mixture when well dried is slowly melted (Meyer's flux) [1].

The flux is dissolved or suspended in water, a current of carbonic acid is introduced, the liquid is filtered off from the undissolved substances (sodium pyrantimoniate and tin oxide). The filtrate contains all the *arsenic* as sodium arseniate (AsO_4Na_3), for the further demonstration of which compare § 471 [2]. The insoluble compounds of tin and antimony are dried on the filter, incinerated in a porcelain crucible, and the ash is fused with potassium cyanide. The metals are thus reduced, and may be weighed. The *tin* [3] dissolves in a little hydrochloric acid; the residue, consisting of metallic *antimony* [4], dissolves in hydrochloric acid with the addition of a little potassium chlorate, forming antimony chloride, and may be precipitated by sulphuretted hydrogen as orange-red antimony sulphide (see § 473).

B. The mercury, lead, copper, silver, bismuth, and cadmium sulphides are insoluble in ammonium sulphide; they are boiled with two-thirds concentrated nitric acid and one-third water.

a. There remain undissolved: black = *mercury* sulphide, HgS; soluble in aqua-regia (see § 466) [5].

" " yellowish grey flakes = sulphur. Burns on a platinum wire with an odour of SO_2.

" " white powder = *lead* sulphate, $PbSO_4$. Formed in small quantities from lead sulphide on boiling in nitric acid. Soluble in basic ammonium tartrate (§ 467).[1]

(*b*.) Lead, silver, bismuth, copper, and cadmium are dissolved and filtered off.

The solution is rendered alkaline with ammonia, any precipitate formed being disregarded, and then rendered strongly acid with an excess of dilute sulphuric acid.

[1] The solutions of lead in basic ammonium tartrate are united and treated as in § 467.

1. Precipitate, white, pulverulent. *Lead* sulphate ($PbSO_4$) [6] (see § 467).

2. The filtrate is mixed with hydrochloric acid. Precipitate, white, flocculent, *silver* chloride [7]. Becomes dark on exposure to light. Soluble in ammonia, reprecipitated by nitric acid. Reactions § 465.

3. The filtrate is rendered alkaline with ammonia.

4. Precipitate white, *bismuth* hydroxide [8]. Its solution in a little hydrochloric acid (HCl) becomes turbid on addition of water (§ 470).

5. Blue colour of filtrate shows presence of copper (§ 468). If there is reason to test for cadmium (in examining yellow colours), we introduce, in the absence of copper, a current of sulphuretted hydrogen, when yellow *cadmium* sulphide is precipitated [9]. If copper is present its precipitation is prevented by adding potassium cyanide until the blue colour disappears (formation of potassium cupro-cyanide [CuCN, KCN]). After precipitating and filtering off the cadmium the *copper* is precipitated with soda-lye [10].

SCHEME III.

The filtrate from the sulphuretted hydrogen precipitate is mixed with much ammonia and solution of ammonium chloride, and then with yellow ammonium sulphide. The precipitate filtered off may contain :—

As Sulphides.	*As Hydroxides.*	*As Phosphates* (If the original substance contained phosphoric acid).
Cobalt, nickel, iron, uranium (black).	Aluminium (white).	Barium (calcium) white.
Manganese (flesh-coloured).	Chromium (green).	
Zinc (white).		

For separation the filter, still moist, having been washed with ammonium sulphide, is placed along with the precipitate in a cold mixture of one volume concentrated hydrochloric acid, and five volumes water.

A. There dissolve as chlorides: chromium, iron, aluminium, manganese, zinc; barium (calcium) and phosphoric acid, if present, pass also into solution. The filtrate is boiled to expel the hydrogen sulphide, and the flocks of sulphur are filtered off. Two preliminary tests are made, each with a small aliquot part of the measured liquid.

1. For chrome, by evaporating down and melting with soda and saltpetre, as in § 461. If chromium is abundant, the change of colour on introducing the sulphuretted hydrogen will have attracted attention, the yellow passing into a green (§ 463).

2. For phosphoric acid: by addition of concentrated nitric acid and ammonium molybdate (§ 185).

If chromium is present it is separated as follows: The solution is

mixed with bromine water (distilled water in which bromine has been dissolved until the colour is a deep brown), supersaturated with sodium carbonate, gently heated and filtered when the liquid has become a pure yellow (no longer green). The filtrate contains all the chrome as sodium chromate; by heating with alcohol and hydrochloric acid the chromate is reduced to chromium chloride, and precipitated with ammonia (§ 478) as greyish green *chromium* hydroxide $Cr_2(OH)_6$ [11].

If no chrome is present, or when the sodium carbonate precipitate, after removal of the chrome, has been dissolved in concentrated nitric acid, the phosphoric acid is separated. For this purpose the liquid is boiled with an excess of the purest tin. There is formed a precipitate consisting chiefly of tin phosphate $[Sn_3(PO_4)_4]$ and tin hydroxide $[Sn(OH)_2]$, along with a little accompanying iron phosphate and aluminium phosphate. The washed precipitate is freed from tin (as tin sulphide) and *phosphoric acid* (as ammonium phosphate) by digestion for two hours with ammonium sulphide; the accompanying ferrous sulphide and aluminium hydroxide remain undissolved; after solution in nitric acid they are added to the filtrate from the tin precipitate [12].

When the phosphoric acid has been removed ammonia and ammonium chloride are added in excess.

1. The precipitate consists of ferric hydroxide and aluminium hydroxide. It is quickly filtered off [13]. For separating *iron* and aluminium dissolve in a little hydrochloric acid and precipitate ferric hydroxide $Fe_2(OH)_6$ by boiling with excess of soda-lye [14]. The filtrate is acidified with hydrochloric acid, and the alumina is precipitated by adding ammonia in excess, and boiling until the liquid no longer smells of ammonia. The precipitate is *aluminium* hydroxide, $Al_2(OH)_6$ [15].

2. The filtrate contains zinc and manganese. It is acidified with acetic acid, and treated with sulphuretted hydrogen. A white precipitate *zinc* sulphide, ZnS [16].

3. The filtrate from 2 mixed with ammonia and ammonium sulphide yields a precipitate of *manganese* sulphide, which, according to quantity and purity, may be yellowish, flesh-coloured, or greenish [17]. If phosphoric acid was originally present, *barium* [18] may be present in the filtrate, which must be remembered during the examination. For reactions, see end of § 481.

B. A black, undissolved residue consists of nickel and cobalt.

Qualitative Recognition.—We dissolve in a little aqua-regia; evaporate almost to dryness and divide into two portions. The one-half is mixed with potassium cyanide until the precipitate formed is redissolved, and then heated to boiling, adding excess of soda-lye and bromine-water. On heating, if nickel is present, black *nickel*-oxide is precipitated (Ni_2O_3) [19]. The other half is boiled with a fragment of caustic potassa, when a blue colour indicates *cobalt* [20].

For quantitative separation and determination, see § 481.

3. Special Reactions of the Elements of Hygienic Importance.

1. SILVER.

§ 465. 1. Hydrochloric acid precipitates white flocculent silver chloride (AgCl), which turns brown or violet on exposure to light (separation of metallic silver), and dissolves readily in ammonia or potassium cyanide.

2. In neutral liquids, potassium chromate precipitates brownish-red silver chromate (Ag_2CrO_4).

3. Sulphuretted hydrogen and ammonium sulphide precipitate black silver sulphide, soluble in hot nitric acid (AgS).

2. MERCURY.

§ 466. Upon sheet copper or brass (brass wool) mercury is deposited from neutral or slightly acid solutions (even in presence of many organic substances, *e.g.*, in urine) on shaking or prolonged standing, as a greyish-white coating which on friction becomes silvery white, and disappears if slightly heated. The brass wool, after being rinsed in water and alcohol and being dried, is heated in a tube of sparingly fusible glass, and the sublimation of the mercury is observed. The reaction is not interfered with by the simultaneous presence of iron, lead, zinc, antimony, arsenic; silver also gives a grey but not volatile coating. A trace of iodine vapour turns the grey coating to a reddish-yellow. (See § 136.)

2. From mercuric salts potassium iodide precipitates scarlet mercuric iodide (HgI_2), and from mercurous salts a greenish-yellow mercurous iodide (Hg_2I_2), both soluble in excess of potassium iodide.

3. Sulphuretted hydrogen or ammonium sulphide precipitates mercuric salts, first whitish, then yellowish, and lastly black. The HgS formed is insoluble in hydrochloric or nitric acid, but readily soluble in aqua-regia. In the mercurous salts sulphuretted hydrogen produces at once a precipitate of black HgS, which encloses metallic mercury in a state of fine division, and which is easily soluble in nitric acid. Yellow ammonium sulphide converts it entirely into black HgS.

3. LEAD.

§ 467. 1. Sulphuric acid precipitates (completely only on addition of alcohol) white lead sulphate ($PbSO_4$), insoluble in water and acids, soluble in potassa-lye and basic ammonium tartrate (the latter reaction distinguishes it from barium sulphate).

2. Hydrochloric acid precipitates white lead chloride ($PbCl_2$), but only from concentrated solution; it dissolves readily in much water, especially if heated (AgCl is insoluble in water). It is insoluble in ammonia.

3. Potassium chromate precipitates yellow lead chromate ($PbCrO_4$) from a neutral, an acetic, or a slightly nitric solution; potassa-lye converts it into the red basic chromate ($PbO + PbCrO_4$); it dissolves in an excess of potassa-lye, especially if heated.

4. Potassium iodide precipitates yellow lead iodide (PbI_2).

5. Sulphuretted hydrogen or ammonium sulphide precipitates black lead sulphide (PbS); in presence of much free hydrochloric acid the precipitate is first red ($PbCl_2 + PbS$), but is gradually entirely converted into PbS. Lead sulphide gradually dissolves in hot dilute nitric acid to $Pb(NO_3)_2$; if very concentrated nitric acid is used a little insoluble lead sulphate is formed at the same time (see 1).

4. COPPER.

§ 468. 1. An excess of liquid ammonia colours a solution of copper blue after in many cases a greenish-blue precipitate of a basic salt has been first produced. Potassa- and soda-lye precipitate blue copper hydroxide [$Cu(OH)_2$], which if boiled passes into black copper oxide (CuO), and is soluble in NH_3.

2. A red deposit of copper is deposited upon bright iron (knife-blades, needles), even from very dilute acid solutions of copper. This reaction is interfered with by the presence of silver, mercury, and antimony, but not by iron, lead, tin, zinc, and arsenic.

3. Potassium ferrocyanide precipitates reddish-brown copper ferrocyanide ($Cu_2FeC_6N_6$), insoluble in dilute acids; very small quantities may be detected by a red-brown colour.

4. Sulphuretted hydrogen and ammonium sulphide precipitate black copper sulphides, whether the solution has an acid or an alkaline reaction. The sulphide is easily soluble in hot nitric acid.

5. CADMIUM.

§ 469. Sulphuretted hydrogen or ammonium sulphide precipitates yellow cadmium sulphide, which, unlike the two other yellow sulphides (As_2S_3 and Sn_2S_3), is *insoluble* in ammonium sulphide, but easily soluble in hot nitric acid.

6. BISMUTH.

§ 470. 1. Sulphuretted hydrogen or ammonium sulphide precipitates brownish-black bismuth sulphide (Bi_2S_3) easily soluble in hot nitric acid.

2. A solution of stannous chloride in soda-lye precipitates black bismuthous oxide (BiO).

3. All solutions of bismuth compounds which do not contain too large a quantity of free acid are decomposed by a plentiful addition of water, a white basic salt being precipitated (*e.g.*, $BiCl_3 + H_2O = BiOCl + 2HCl$).

Tartaric acid does not prevent the precipitation by water (a distinction from antimony). An excess of potassa- or soda-lye does not render clear solutions of bismuth which have been made turbid by the addition of water; there is formed $Bi(OH)_3$ bismuth hydroxide. (Difference from stannous salts.)

4. Potassium chromate precipitates yellow bismuth chromate, easily soluble in dilute nitric acid, insoluble in potassa-lye. (Difference from lead chromate.)

7. ARSENIC.

§ 471. The distinction between arsenious acid (As_2O_3) and arsenic acid (As_2O_5) is unimportant for hygiene, as the latter acts physiologically like the former, though more slowly. It is, therefore, sufficient if we detect arsenic in either form.

In consequence of the delicacy of arsenic tests employed, blank experiments must always be made beforehand to check the reagents sold as free from arsenic (zinc, acids,

&c.)[1]; *i.e.*, no tests can be accepted as valid if they succeed with the reagents alone.

As the material for the detection of arsenic we take either scrapings of colour or extracts with concentrated ammonia filtered and evaporated down (Gutzeit and Flückiger). Dragendorff recommends that the finely comminuted substance should be first evaporated down to dryness in a porcelain capsule on the water-bath with nitric acid (of specific gravity, 1·4), then placed in a boiling flask and extracted for two hours. To 100 *scm.* of wall-paper or 200 *scm.* of woven tissue there is used at first 50 *cc.* of nitric acid, and then as much sulphuric acid. It is, of course, most accurate to use the sulphuretted hydrogen precipitate from Fresenius-Babo's digestion after its oxidation (Meyer's Flux, § 464 A).

For preliminary investigations it is sufficient to use paper-hangings, textile goods, &c., directly if the proportion of arsenic is appreciable.

1. The substance in question (tissue, paper, pigment) is placed in a test-glass, covered with dilute sulphuric acid, a piece of zinc, free from arsenic, about the size of a pea is dropped in, the glass is closed with a perforated caoutchouc stopper, through which there passes a tube drawn out to a point, and the escaping hydrogen mixed with arsenic hydride is ignited as soon as we are sure that all the atmospheric air has been expelled. One or several cold lids of porcelain crucibles must be moved slowly over the flame, when brownish or blackish spots ("mirrors") are formed and are further examined (§ 472). As small a quantity as $\frac{1}{100}$ *mgrm.* may thus be detected.

2. *Gutzeit's Reaction.*—We pour into a capacious test-glass 3 *cc.* hydrochloric acid and 6 *cc.* water, mixed with a little iodised potassium iodide, until the colour becomes yellow; a little zinc is added, a stopper of cotton-wool is quickly

[1] The physician will be rarely required to prepare his own reagents (see Baumert), but he should always test them. Barium sulphide for the preparation of pure hydrogen sulphide may now be bought.

thrust into the upper section of the tube, and a piece of white blotting-paper, moistened with a drop of concentrated solution of silver nitrate (1 nitrate + 2 water) is laid over the mouth. There then appears a lemon-yellow spot ($Ag_3As + 3\,AgNO_3$) with a brownish margin, which becomes at once black if moistened with water (separation of silver). The reaction (for details see § 472) must be produced in the absence of direct sunlight. If the proportion of arsenic is very small, *i.e.*, if the reaction does not at once appear, the glass is placed in a shut-up closet, from which it is taken out for examination every five or ten minutes. In a blank experiment no yellow colour should appear in thirty minutes. $\frac{1}{100}$ *mgrm.* arsenic is very distinct, and $\frac{1}{1000}$ *mgrm.* can still be recognised after some time. At the same time the odour of garlic is observed. The filter-paper should not have been kept in the laboratory for any length of time, as substances may be taken up, especially from coal-gas, which, without containing arsenic, may simulate its reactions (Curtmann, *Chem. Zeit. Repertorium*, 1891, p. 82).

3. An analogous reaction (although sufficiently sensitive for sanitary purposes, and not affected by light and water) is obtained by using a solution of mercuric chloride (1·20) instead of the silver solution, the procedure being otherwise quite similar. Arsenic is shown by a yellow colour which becomes brown.

4. *Bettendorf's Reaction.*—The suspected substance is dissolved in concentrated hydrochloric acid, and a piece of the purest tin-foil is added. In presence of arsenic there appears a brown coloration, or the separation of brown flocks, which consist of stanniferous arsenic. The method is much recommended for examining the "non-arsenical" hydrochloric acid. Instead of tin a pasty solution of stannous chloride in concentrated hydrochloric acid is frequently used, saturated with washed hydrochloric gas, and filtered through asbestos. The German *Arzneibuch* (*Pharmacopœia Germanica?*) requires that no brown colour should appear in an hour. (Bettendorf's reaction; for a criticism of this reaction see *Chem. Zeit. Repert.*, 1890, p. 352, and 1891, pp. 33 and 256.)

The chief objection to Bettendorff's reagent is that it has in itself a yellowish colour, and that a series of non-arsenical substances—acetates, phosphates, glycerine, calcium phosphates, &c.—produce a slight dark coloration.

The chief method for an exact qualitative determination is still that of Marsh, which must therefore be briefly described. The apparatus is shown in Fig. 126.

Into the gas-generating flask there plunges an open funnel-tube; *b* is a tube filled with calcium chloride to retain water; the tube *c, d, e* is made of sparingly fusible potash glass about 7 *mm.* internal diameter by drawing it out in some places to a diameter of from 1 to 1½ *mm.* internal width. Into the flask *a* there are put about 10 *grm.* zinc free from arsenic, and from 10 to 15 per cent. of pure hydrochloric or sulphuric acid, so that a slow current of hydro-

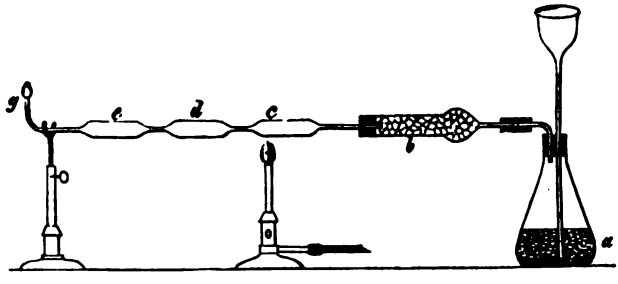

FIG. 126.—Marsh's Apparatus.

gen is evolved.[1] We wait for thirty minutes until all the air is expelled, and heat then for one hour, keeping up a gentle current of gas. Heat is applied in one, or in a second place immediately in front of a contraction of the tube (Fig. 126). If arsenic is present it appears in the contracted parts as a brownish, blackish, or black coating.

When the reagents have been found free from arsenic the flask is almost entirely emptied, fresh zinc is introduced, if needful, and after the air has been expelled (in about fifteen minutes) the substance in question is dissolved in hydro-

[1] The purer the zinc the slower is the current, but it may be accelerated by platinising the zinc before the experiment. For this purpose the fragments of zinc are covered with dilute sulphuric acid, and a couple of drops of platinum chloride are added. As soon as the escape of gas becomes violent the zinc is removed from the liquid, washed, and dried.

chloric acid, is poured in slowly, and in portions through the funnel-tube.[1]

As in the preliminary experiment we endeavour to obtain several deposits of arsenic (mirrors), for which a very short time is sufficient if the proportion of arsenic is not quite a minimum. The escaping gas is then lighted at *g* (Fig. 126), and some cold lids of porcelain crucibles are held in the flame, which, if arsenic is present, has a bluish white colour. Arsenical spots are again formed. Finally the flame may be extinguished, and the gas passed into a solution of silver nitrate, slightly acidified with nitric acid. The liquid becomes turbid from the deposition of silver, and after filtration takes a yellow colour on the addition of ammonia drop by drop.

The conditions for the success of Marsh's reaction are the slow, uniform development of the gas, the absence of oxidising agents, and substances which yield sulphuretted hydrogen.

§ 472. Although by preparing Meyer's flux (§ 464*a*), we may in every important case exclude from the outset the possibility of confounding the arsenical spots with those of antimony, since no antimony enters into solution, we test each time for the most important reactions of antimony according to the following conspectus:—

DISTINCTION OF ARSENIC AND ANTIMONY BY MEANS OF THE MARSH APPARATUS.

Arsenic.	*Antimony.*
AsH_3 has a strong smell of garlic.	SbH_3 is inodorous.
AsH_3 burns with a bluish white flame.	SbH_3 colours the flame greenish white.
AsH_3 is absorbed by solution of silver nitrate; silver being deposited with a blackish colour, whilst arsenious acid remains in solution.	SbH_3 is absorbed by silver nitrate, black silver antimonide being deposited.

[1] Dragendorff recommends the 50 *cc.* of arsenical maceration liquid to be introduced at once, and that heat should be applied at once (after shaking up the flask) for exactly ten minutes, to the place in front of the first contraction of the reduction tube. See § 485.

Arsenic.

$AsH_3 + 6\ AgNO_3 + H_2O = 6\ Ag + 6\ NO_3H + AsH_3O_3$.

When the filtrate is neutralised with ammonia yellow Ag_3AsO_3 is deposited.

Arsenical spots only *behind* the heated place, shining brownish black or brown; volatile if heated in a current of hydrogen; garlic smell.

Soluble without colour in a solution of sodium hypochlorite.[1]

In contact with iodine vapour, the spot gradually changes into yellowish brown arsenious iodide, which is decolorised if breathed upon. If a drop of strong sulphuretted hydrogen water is then applied to the spot yellow arsenic sulphide is formed.

Antimony.

$SbH + 3\ AgNO_3 = Ag_3Sb + 3\ NO_3H$.

If the precipitate is dissolved in tartaric acid it yields with sulphuretted hydrogen orange red antimony sulphide.

Antimonial spots: partly before the heated place. Velvet black; not readily volatile if heated in a current of hydrogen; inodorous.

Not affected by sodium hypochlorite.

On similar treatment there is formed reddish brown antimonious iodide which does not disappear if breathed upon. It is changed into orange red antimony sulphide by a drop of strong sulphuretted hydrogen water.

8. ANTIMONY.

§ 473. 1. A white basic salt is thrown down from solution of antimonial salts by an excess of water. Tartaric acid dissolves the precipitate or prevents its formation (distinction from bismuth).

2. If no free nitric acid is present, antimony in a hydrochloric solution, placed in the concavity of a platinum lid, can be deposited upon the platinum as a brown or black coating by means of metallic zinc. The spot is insoluble in hydrochloric acid, easily soluble in nitric acid.

3. Sulphuretted hydrogen precipitates orange-red antimonious sulphide (Sb_2S_3), or antimonic sulphide (Sb_2S_5), soluble in ammonium sulphide.

4. It is best recognised in the Marsh apparatus, like arsenic, from which it must have been previously separated, as in § 464. For its distinction from arsenic, see § 472.

[1] Sodium hypochlorite is obtained by rubbing up chloride of lime with soda-lye and filtering the liquid, which is slightly alkaline.

9. TIN.

§ 474. 1. Nitric acid with heat separates out white meta-stannic acid (H_2SnO_3), which on ignition passes into stannic oxide SnO_2.

2. Metallic zinc precipitates tin from a hydrochloric solution. The black deposit of tin does not adhere to platinum as does antimony.

3. If salts of tin are suspended in a bead of phosphatic salt, moistened with solution of cobalt nitrate, and held in the oxidising flame of the Bunsen burner, the melt takes on ignition a bluish green colour (see Cobalt).

4. Sulphuretted hydrogen precipitates from the stannous salts a brownish black stannous sulphide (SnS), but from the stannic salts yellow stannic sulphide (SnS_2), both soluble in ammonium sulphide, or in hot concentrated hydrochloric acid.

10. IRON.

§ 475. 1. Ferrous salts take a deep blue colour (Turnbull's blue $Fe_3(FeC_6N_6)_2$) with potassium ferricyanide and hydrochloric acid; but take no colour with potassium sulpho-cyanide.

2. Ferric salts take a deep blue with potassium ferro-cyanide and hydrochloric acid [Prussian blue $Fe_4(FeC_6N_6)_3$]; potassium sulpho-cyanide gives a blood-red colour [formation of $Fe_2(CNS)_6$].

3. Sodium acetate gives a dark red colour with formation of ferric acetate; on boiling with an excess of sodium acetate, all the iron is precipitated as basic iron acetate $Fe_2(OH)_4(C_2H_3O_2)_2 + 4\ C_2H_4O_2$.

4. Ferrous and ferric salts give black precipitates with ammonium sulphide, but not with sulphuretted hydrogen in acid solution.

11. COBALT.[1]

§ 476. Very small quantities of cobalt salts, if melted in a loop of platinum wire, colour melted phosphatic salt or borax (a so-called bead) a splendid blue.

2. Salts of cobalt mixed with an excess of potassium cyanide, and a little yellow ammonium sulphide, take a blood-red colour. Further reactions in Scheme III. [20].

[1] In the separation of nickel and cobalt (§ 481) a series of reactions of these metals are described.

12. NICKEL.

§ 477. Potassa- and soda-lye precipitate pale green nickel hydroxide $Ni(OH)_2$, insoluble in an excess of the solvent.

No characteristic coloration of the borax bead. Further reactions in Scheme III. [19].

13. CHROME.

§ 478. 1. Chromium oxide salts are entirely precipitated by ammonia on ebullition; the precipitate [chromium hydroxide $Cr_2(OH)_6$] is greyish green; the supernatant liquid is at first green or reddish violet, but becomes colourless when the precipitation is completed.

2. If we melt compounds of chromic oxide with potassium nitrate and soda, there is formed potassium chromate, K_2CrO_4 giving a yellowish solution in water, which forms a yellow precipitate with lead acetate ($PbCrO_4$) (compare § 467). If boiled with hydrochloric acid and alcohol, a greenish solution of chromium chloride is formed precipitable as in 1.

3. For detecting traces of chromic acid the solution is concentrated as much as possible, and dropped into a dilute acidified (sulphuric acid) solution of hydrogen peroxide, upon which floats a thin stratum of ether. The blue coloration formed in the lower stratum passes over to the ether if slightly shaken. See § 132.

14. ZINC.

§ 479. 1. Zinc salts, if moistened with cobalt nitrate and ignited upon wood charcoal, yield, without melting, masses of a fine green colour (Rinmann's green).

2. Sulphuretted hydrogen and ammonium sulphide precipitate white zinc sulphide (ZnS) from acetic, neutral, or alkaline solutions of zinc, but not from a hydrochloric liquid.

15. MANGANESE.

§ 480. 1. If manganese is fused upon platinum foil with soda and a little saltpetre, there is formed a bluish green mass (sodium manganate Na_2MnO_4).

2. If red lead is heated with an excess of nitric acid, and there is added a trace of manganese salt, or a liquid (free from ammonium chloride) to be tested for manganese, the liquid assumes an intense purple red colour, due to the formation of permanganic acid. The colour becomes more distinct after the excess of the red lead has subsided.

3. Ammonium sulphide precipitates a hydrated yellowish-white manganese sulphide (MnS), which in large quantities appears of a flesh colour, and becomes brown on drying. Sometimes the flesh-coloured precipitate becomes converted into the green, anhydrous sulphide even in the cold, or more rapidly if boiled.

4. The Quantitative Determination of the most Important Elements.

(*a.*) GENERAL METHODS.

§ 481. 1. *Electrolytic Separation as a Metal.*—If a moderately strong galvanic current is passed through a dilute nitric solution of certain metals, silver and copper are deposited at the positive electrode (platinode) as metals, and lead peroxide at the negative electrode, in a form which, after desiccation, admits of direct weighing. Mercury, zinc, nickel, and other metals can be thus determined, but the methods which also require special arrangements are neither so necessary nor so general in hygienic work as to require here a particular description. See—

CLASSEN, A., *Quantitative chemische Analyse durch Elektrolyse.* 3rd edit. Berlin. 1892.

2. *Weighing as Sulphide.*—The sulphides obtained from a great number of metals, by precipitation with sulphuretted hydrogen, are not adapted for weighing, as they become partially oxidised whilst drying; mercury sulphide forms an exception. To avoid this defect they are heated (after the sulphuretted hydrogen precipitates have been heated in a crucible of Berlin porcelain, along with the filter, until the latter is completely consumed) with powdered roll-sulphur free from ash (about 3 to 5 *grm.*), in a current of hydrogen in a Rose crucible. A Rose crucible is made of unglazed porcelain, and has a perforated lid, through which a porcelain

tube is introduced. After a strong current of hydrogen (dried by a passage through concentrated sulphuric acid) has been passed in, the crucible is heated, when the hydrogen takes fire. After about thirty minutes, when the sulphur is consumed, the substance is allowed to cool in a current of hydrogen, and weighed as sulphide. This method is well suited for copper, lead, and zinc.

3. The hydroxides or oxides are precipitated by boiling with potassa-lye or ammonia, filtered off, dried, and converted into oxides by ignition. This procedure is available, *e.g.*, for copper, iron, nickel, chrome.

4. The oxides or sulphides are reduced to the metallic state by ignition in a current of hydrogen (Rose's crucible), *e.g.*, silver, cobalt, nickel, copper (compare § 219).

5. The majority of metals, when present only in small quantities, may be approximately determined by colorimetric methods, founded on their most sensitive colour reactions. See, *e.g.*, a colorimetric determination of iron, § 195.

(*b.*) SPECIAL METHODS.

Silver. Precipitate as silver chloride with hydrochloric acid, stirring well; allow it to subside in the dark, filter, detach the precipitate from the paper, ignite, and weigh as AgCl. Any portion which still adheres to the filter is dissolved in a minimum of nitric acid after the paper has been burnt, precipitated with hydrochloric acid, washed by decantation, united with the bulk, fused along with the latter in a porcelain crucible, and weighed as AgCl.

Mercury. As mercuric sulphide HgS, direct as it is obtained according to Scheme II. [5], after it has been freed from lead sulphate by treatment with ammonium tartrate, and from any adhering sulphur by treatment with carbon disulphide. It is dried on weighed filter at 100°, and weighed. Mercuric chloride is soluble in ether.

Lead. 1. Very small quantities may be determined colorimetrically as lead sulphide. We make a solution of 0·160 *grm.* lead nitrate in 1 litre, *i.e.*, 0·1 *mgrm.* lead per cubic centimetre as a comparative solution, and add one or several cubic centimetres to portions of 100 *cc.* water, adding to each 5 *cc.* of soda-lye free from iron, and 5 *cc.* of strong sulphuretted hydrogen water. The same is done with the solution of lead in question made up to 100 *cc.*, and the brownish-black shades of colour are compared. On the addition of alkali as little as 0·01 *mgrm.* may be recognised in 100 *cc.* by the brownish colour. The filters must of course be free from iron.

2. Larger quantities are determined as lead sulphide according to § 481, 2, or:

3. The lead sulphide is dissolved in nitric acid of a moderate degree of concentration, evaporating off the greater part of the acid; the liquid is diluted with water, filtered, and the lead is precipitated as lead sulphate by means of sulphuric acid in presence of alcohol.

Copper. 1. Very small quantities may be determined colorimetrically as copper ferrocyanide. A solution is prepared by dissolving 1·971 *grm.* copper sulphate ($CuSO_4 + 5H_2O$) in 1 litre. Of this 1 *cc.* = 0·5 *mgrm.* copper. 100 *cc.* of water are mixed with varying proportions of this solution, and to each of these, as well as to the cupriferous liquid made up to 100 *cc.*, there is added 1 *cc.* of a dilute solution of potassium ferrocyanide. The solutions must be so weak as to give merely colorations, but not precipitates. 0·1 *mgrm.* is thus distinctly shown in 100 *cc.* The presence of nitric acid interferes.

2. Copper may also be determined colorimetrically with ammonia as blue cupric oxide ammonia. This method has the advantage that the copper can be afterwards determined in any other manner, as the addition of ammonia, unlike that of potassium ferrocyanide, does not interfere with other reactions.

3. Electrolytically (commencement of § 481).

4. By boiling with an excess of potassa-lye as copper oxide (same §). The black cupric oxide must not be ignited along with the filter.

5. Volumetrically, as copper sulphate. Cupriferous precipitates are dissolved in nitric acid, the copper nitrate after the abundant addition of ammonium sulphate is evaporated to dryness, and further heated upon an asbestos plate, when ammonium nitrate is volatilised and copper sulphate is formed. The copper sulphate is dissolved in water with 10 *cc.* of a colourless saturated solution of potassium iodide, when iodine is disengaged and copper iodide is formed—

$$CuSO_4 + 2KI = CuI + K_2SO_4 + I.$$

The free I is titrated with decinormal sodium thiosulphate (according to § 135); as often as 1 *cc.* of this solution is consumed 12·57 *mgrm.* iodine are recognised = 6·3 *mgrm.* copper. (I have often used with advantage this method by de Haën.)

Arsenic.[1] 1. We supersaturate the filtrate from Meyer's flux with ammonia, add magnesia mixture, collect on a small filter the precipitate, which is deposited on standing for twenty-four hours in the cold (ammonium magnesium arseniate), wash with very dilute ammonia, and proceed exactly as directed in § 190 for the treatment of ammonium magnesium phosphate. The magnesium pyr-arseniate ultimately obtained by ignition contains 48·41 per cent. of arsenic.

2. Mayrhofer has recently proposed to convert the arsenic into arsenic hydride, to conduct it into an acidified standard solution of silver

[1] The German official method (Baumert) is scarcely used on account of its tediousness.

nitrate and determine the loss of strength in the latter, occasioned by the precipitation of metallic silver by the arsenic hydride. The titration is effected as according to Volhard with potassium sulphocyanide. See *Bericht über die VII. Versammlung Bayr. Chem. in Speyer*, 1888, p. 141.

Antimony. 1. We weigh the metallic antimony contained according to § 464, A. [4].

2. Or we precipitate the metallic antimony from the precipitate of antimony sulphide (dissolved in hydrochloric acid with the addition of a little potassium chlorate) by the introduction of pure metallic iron (binding-wire). The blackish metal deposited is collected on a weighed filter, washed with dilute hydrochloric acid, and afterwards with water, dried in the filter, and weighed.

Tin. On dissolving alloys in nitric acid tin remains perfectly insoluble as white metastannic acid (SnO_3H_2). When filtered, ignited, moistened with nitric acid, and again ignited, it becomes tin oxide (SnO_2), in which state it is weighed.

Iron. 1. Small quantities colorimetrically, according to § 195.

2. Larger quantities are precipitated as ferric hydroxide, according to Scheme III. [14], and converted into ferric oxide by ignition in a porcelain crucible.

3. The volumetric process is also convenient. We boil the iron hydroxide in a flask with zinc and sulphuric acid, without removal of alumina, whereby there is formed greenish ferrous hydroxide. The reduction is complete when a drop of the solution is no longer reddened by a solution of potassium sulphocyanide.

We now dissolve 1·5 *grm.* potassium permanganate in 1 litre, and ascertain its standard by a fresh solution of dry, well-crystallised ferrous ammonium sulphate, of which 700 *grm.* are dissolved in 1 litre. Such a solution contains per litre exactly 1 *grm.* iron in the ferrous state. It consumes for oxidation exactly as much oxygen as a solution containing 1·125 *grm.* oxalic acid, which may also be used instead of the ferrous ammonium sulphate. We mix 50 *cc.* of the oxalic acid, or ferrous ammonium sulphate solution, with an excess of sulphuric acid, and add now (after heating to ebullition if oxalic acid has been used) permanganate solution until a permanent reddening appears. We use about 46 *cc.*

In titrating our reduced solution of iron, which we decant away from the zinc without filtering, and titrate as rapidly as possible without heating, the consumption of each 46 *cc.* solution of permanganate signifies 50 *mgrm.* of iron. More dilute solutions can be used for very small quantities of iron. Compare § 195.

Aluminium. The alumina, $Al_2(OH)_6$, which has been precipitated, is ignited, weighed as Al_2O_3, Scheme III. [15]. If iron is present the mixture $Al_2O_3 + Fe_2O_3$ is weighed according to Scheme III. [18], the iron is titrated as above, recalculated as Fe_2O_3, and deducted. The remainder is Al_2O_3.

Cobalt and Nickel. If only one of these metals is present in the

mixture thrown down by sulphuretted hydrogen, according to Scheme III. [19] and [20], we proceed as follows :—

1. **Nickel.** Dissolve in hydrochloric acid, heat with an excess of soda-lye almost to ebullition in a porcelain basin, wash the apple-green nickelous hydroxide very well out by decantation, filter, dry, incinerate apart from the filter, and weigh after ignition as nickelous oxide (NiO).

2. **Cobalt.** We proceed at first as above, but we avoid a great excess of soda-lye, and boil until brownish-black cobalt oxide separates out; filter, wash very well, ignite with the filter, and then convert it into metallic cobalt in a Rose crucible in a current of hydrogen, but without the addition of sulphur.

If both metals are simultaneously present they are jointly precipitated with soda-lye, converted together into metals in a Rose crucible, without the addition of sulphur, and weighed. They are dissolved in aqua-regia, neutralised with potassa-lye, a concentrated solution of potassium nitrite is added in excess, as also a little acetic acid. If the precipitation is complete after standing for twenty-four hours in a warm place, we collect the yellow cobalt potassium nitrite ($Co_2(NO_2)_{12}K_6$) upon a filter, wash with dilute sodium acetate (1 : 9) and potassium nitrite, incinerate the desiccated filter along with its contents, dissolve in hydrochloric acid, precipitate cobalt hydroxide with KOH as above, and convert it according to 2 into cobalt capable of being weighed. Cobalt + nickel − cobalt = nickel.

Chrome. Soluble salts of chromium oxide are boiled in a porcelain capsule with an excess of ammonia, according to § 478; the chromium hydroxide separated out is converted into chromic oxide, Cr_2O_3, by ignition in a porcelain crucible. Chromic acid and its salts are previously reduced according to § 464 [11].

Zinc. 1. Very small quantities of zinc are determined colorimetrically. For this purpose 4·415 *grm.* zinc sulphate ($ZnSO_4 + 7H_2O$) are dissolved in 1 litre (*i.e.*, 1 *mgrm.* zinc in 1 *cc.*), and 100 *cc.* of water are mixed with varying proportions of this solution. Largely diluted solutions of zinc give, with potassium ferrocyanide, whitish turbidities, from the intensity of which in 100 *cc.* an approximate estimate may be deduced.

2. The zinc chloride, obtained from zinc sulphide (Scheme III. [16]) by treatment with hydrochloric acid, is converted into zinc carbonate, the bulk of the acid being first neutralised with soda-lye, the liquid heated in a porcelain basin almost to ebullition, when an excess of soda-lye is gradually added. The zinc carbonate, filtered off according to the rules in § 7, is placed in a porcelain crucible and ignited until the weight is constant; the zinc oxide (ZnO) is weighed. Or according to Rose (§ 481, 2).

Barium. After separating out the heavy metals, according to Schemes I. and II. (iron and phosphates being chiefly concerned), by precipitation with sulphuric acid, barium sulphate is treated according to § 176. Flour must always be examined according to § 327. The examination of a portion of the original material in dilute hydrochloric acid for soluble compounds of barium must never be omitted (§ 461).

B. Decision on Inorganic Substances.

§ 482. The following section considers the toxicology of the elements above described only from the following points of view:—

1. Only the compounds of the greatest hygienic importance are discussed, *i.e.*, chiefly those substances solely which may come into play in the household, and among these only the concentrations which actually occur in the household.

2. We treat merely of the introduction of substances by way of the digestive organs, by respiration, or of the uninjured skin and mucous membranes. All artificial ways of introduction (subcutaneous injection) are left out of consideration.

3. Here and there only supplemental notes referring to industrial hygiene are introduced for the sake of completeness.

It is very striking how insufficient is our knowledge of many of the poisons to be here considered. Especially concerning copper, zinc, and tin we may read the most contradictory assertions. According to my own experience in case of copper (§ 484), I am inclined to suppose that a series of cases have been falsely ascribed to poisonings by small quantities of metal. In general merely extremely small quantities even of the more soluble salts of the heavy metals are absorbed and pass into the organism. The maximum of the above-named metals, which we find in the entire body in acute and even in chronic poisoning cases, does not exceed a few milligrammes, not considering the quantity present in the liver.

It must, of course, be admitted as possible that there may occur in some persons an abnormally high sensitiveness for certain metals or metallic salts, just as a similar phenomenon occurs for very many other poisonous substances (e.g., *Urticaria*) after the consumption of cray-fish soup (*Astacus fluviatilis*) of strawberries, &c., and that a portion of the mysterious poisoning cases by metals which

we find in literature may thus be explained. It is further conceivable that possibly certain metallic compounds, as yet scarcely known, which might occur in food, are more readily absorbed than others. Especially large doses may occasionally exert a corrosive action upon the mucous membrane, and may thus occasion increased absorption. But at present, in the majority of cases, we cannot decide among these possibilities. Very interesting facts which are here appropriate are found collected in Lewin's book, *Nebenwirkungen der Arzneimittel*, 2nd ed., Berlin, 1892. Many facts are explained, but the majority of observations are as yet unintelligible.

In case of poisoning by foods, which contained mere traces of metals, we have, in addition to the phenomena discussed, to keep in view the possible action of a ptomaine. I must confess that the latter, where it is possible under the circumstances, seems to me worthy of the greatest attention. I am even convinced that a series of supposed poisonings by metals are in reality due to the action of decomposed foods.

MERCURY.

§ 482 *a*. Mercury comes into action in the household at the utmost when opportunity is given for its evaporation by the breakage of a barometer, &c. (see § 137). The greater are the sufferings of workmen who use metallic mercury—the makers of mirrors, thermometers, &c. Minimum quantities of mercury evidently suffice for chronic poisoning. Tin containing mercury has recently occasioned severe cases of poisoning when melted (R. Kayser). The soluble salts of mercury act like the metal. Mercurous nitrate occasions the disease of men employed in dressing hair-skins.

Cinnabar, the red modification of mercury sulphide HgS, used as a pigment, is insoluble, and may be consequently considered as non-poisonous.

LEAD.

§ 483. Metallic lead dissolves in distilled water in presence of carbon dioxide and air, and also in the most various kinds

of drinking waters, unless solution is prevented by a large percentage of calcium bicarbonate. The latter, however, is not a perfect protection if the vessel is not entirely filled with water, and if air has access.

All organic acids dissolve lead, not merely pure lead, but the alloys of lead and tin (tinned utensils, plumbiferous solder), the more the larger the proportion of lead and the more abundant the access of air. The corrosion is greatest when the metal is alternately wetted and exposed to the air, and when the temperature is high. On prolonged standing the lead in alloys is in part reprecipitated by the tin. The quantitative results of such experiments vary considerably in different authors according to the conditions of the experiment; if the proportion of lead is low (about 10 per cent. or less) mere traces of lead are dissolved by vinegar in the course of a few hours.

Glazed and enamelled vessels may yield very considerable quantities of lead. Thus, *e.g.*, Fleck obtained from a vessel holding about 1 litre, on boiling three times in succession (§ 460), 17·2, 15·1, and 12·3 *mgrm.* of lead. There are even on record cases (Schramm) where a culinary vessel of earthenware containing $\frac{3}{4}$ litre yielded in twenty-four hours 1·47 *grm.* lead.

The cause of the extraction of lead is partly the use of bad materials, but still more imperfect burning. An extraction of lead has even been observed in cases of vessels of enamelled iron. Lead is very often present in the glaze or the enamel, but that need not concern us if nothing is dissolved out on the official trial, as it is then insoluble.

The agitation commenced by W. Schultze against the use of plumbiferous glass for beer glasses is quite unjustifiable; the minimum traces of lead alleged to pass into solution are quite irrelevant. (See Amthor, *Ch. Zeit.*, 1890, No. 69.)

Among the compounds of lead which are economically important, the salts of the common organic acids are readily soluble in water. Dilute acetic acid dissolves also reddish yellow litharge (lead oxide, PbO), red lead (minium, Pb_3O_4), white lead (basic lead carbonate, $PbCO_3 + PbO$).

Hydrochloric acid converts all the above-mentioned compounds into sparingly soluble lead chloride. It also splits off lead chloride from chrome-yellow ($PbCrO_4$) and chrome-red ($PbCrO_4 + PbO$), setting free the chromic acid. Lead chloride is sparingly soluble in water; but even lead sulphate, though exceedingly difficult to dissolve, is soluble enough to give rise to chronic lead poisoning.

Acute lead poisoning is very rare in domestic life, as for it large quantities of the salts of lead are necessary on account of their difficult absorption, when their bad taste acts as a warning. An acute poisoning may at most be occasioned by vinegar, wine, &c., which have been allowed to stand in leaden vessels. The symptoms are exactly those of copper and zinc poisoning. The literary statements concerning acute poisonings by small quantities of lead chromate appear improbable. Kern, in my laboratory, observed only transitory affections in dogs on the administration of 5 *grm.* in one dose, and in cats by 2 *grm.* He took personally 0·1 *grm.* at once without any result.

The more important and more common is *chronic lead poisoning*, which may be occasioned by every preparation of lead, on the ingestion of extremely minute quantities, if only continued for a sufficient time. We may admit with Brouardel that even 1 *mgrm.* of lead acetate daily may suffice in some months for poisoning, whilst 0·2 to 0·4 *grm.* taken in the course of a single day occasions at most vomiting, and was formerly often prescribed as a styptic and anti-diarrhœic.

We can scarcely imagine a method in which chronic lead poisoning has not already been effected.

The well-known symptoms are: a slate-grey border on the gums, lead colic, violent pains in the joints, lead paralysis (especially of the extensors of the wrist), and finally, injury to the brain, shrinkage of the kidneys, &c.

According to the above, lead and compounds of lead, even in the smallest traces, are to be condemned in all substances destined for ingestion, and to be banished as completely as possible from the household, but certainly from the kitchen

and the dining-room. The prescriptions of the Imperial law (§ 458) seem to me defective in one point only, there is no prohibition against the use of lead chromate in dyeing tissues. It is quite conceivable that danger may threaten not merely the maker of the clothes or yarns, but also the wearers.

The symptoms of poisoning by lead chromate in man combine those of lead and of chrome. In the lower animals I obtained with it merely pure lead poisoning. Among thirty-four yellow tissues procured in Würzburg eight contained lead chromate in plenty; a sample of cotton yarn contained in 100 *grm.* not less than 16 *grm.* lead and 8 *grm.* chrome! Compare more detailed statements on record, K. B. Lehmann, *Archiv f. Hygiene*, xvi.

In toys protected with a good linseed oil varnish it can scarcely occasion danger. Linseed oil varnish, prepared by boiling linseed oil with lead oxide, certainly contains lead, but in a very sparingly soluble form[1] and a very minute quantity; further a very small quantity is sufficient for a coating.

Concerning the admissibility of lead water-pipes, in case of hard water poor in free carbonic acid, I have given my opinion in various passages (see Index). For a brief discussion of all separate cases of the entire question see Dragendorff, p. 445.

COPPER.

§ 484. Metallic copper, whether pure or alloyed with tin (bronze) or with zinc (brass, pinchbeck), is very sparingly soluble in water.

In presence of air, however, copper dissolves well in dilute organic acids, in the fatty acids of rancid fats; even moist carbonic acid forms basic copper carbonate (genuine verdegris). Its ready solubility in all the mineral acids is known; copper chloride may be formed by means of acetic acid and sodium chloride. Salts of copper are blue or green.

[1] Instead of litharge a preparation of manganese is now very generally used in the manufacture of linseed oil varnish. The danger of lead poisoning by its use is thus totally removed.—*Editor.*

Among the salts the chloride, sulphate, nitrate, and the salts of organic acids dissolve readily in water; the basic acetates (the green and blue verdegris of commerce) form with excess of water a solution of copper acetate and a separation of more strongly basic acetates.

Weak hydrochloric acid dissolves also copper hydroxide (Bremer blue), basic copper carbonate (mountain-blue and mountain-green), basic copper acetate, copper arsenite $(AsO_3)_2Cu$ = Scheele's green, the double compound of copper arsenite and copper acetate (Schweinfurt green). See Arsenic.

Copper oxide (CuO) is very sparingly soluble in the liquids of the body, and copper sulphide is insoluble.

Acute Poisoning.—Such a result cannot be produced by the metal, or by the sparingly soluble preparations (copper oxide, &c.)[1] Doses of the readily soluble compounds corresponding to from 10 to 30 *mgrm.* of copper suitably diluted and with correctives for the taste have, in general, no action. In doses of from 50 to 100 *mgrm.* Cu, and in a concentrated form, they certainly occasion sickness and vomiting. From 0·2 to 0·3 *grm.* of copper sulphate are given several times in quick succession as an emetic. As much as 2½ *grm.* copper sulphate in from five to six days is frequently given in croup. Otherwise it generally occasions no disturbance. There is no case on record in which a healthy adult has been seriously injured by doses of 200 *mgrm.* Cu.

After the ingestion of 132 *mgrm.* Cu in 200 *grm.* of peas, coloured even with copper acetate, there occurred no disturbance beyond a strong coppery taste lasting for some hours, and vomiting after three hours. A medical practitioner in my laboratory consumed in two meals the same weight of copper boiled up in meat. He experienced no symptoms at all. I have calculated that in the very rarest case of a full meal in which all the ingredients contained a maximum proportion of copper, about 190 *mgrm.* might be ingested.

[1] Some desultory observations seek to refer chronic affections of the stomach to a copper coin which has remained in that organ.

Larger quantities would at once betray themselves by the taste; 1200 *mgrm.* of Cu, corresponding to 5 *grm.* copper sulphate, is the smallest authenticated dose which has occasioned copper-poisoning in an adult.

An especial toxicity of copper chloride, acetate, butyrate, oleate, or lactate could not be traced in experiments made in my laboratory on dogs, cats, rabbits, and on men. The soluble copper albuminates act, according to Feltz and Ritter, about like copper ammonium sulphate.

Chronic Poisoning.—Neither in man nor in the lower animals have injuries been observed in any series of experiments in consequence of small or medium doses from about 50 to 100 *mgrm.* daily, after a little vomiting in the first days. Even doses of several decigrammes (from 3 to 5) of copper ammonium sulphate[1] taken for some months (Bourneville) occasioned no severe disturbances. There occurred at most some transitory intestinal affections. Toussaint (*Vierteljahr. f. ger. Med.*, 1857) was not able to produce chronic poisoning in himself by very large doses of salts of copper. It must be remembered that

[1] The system rapidly becomes habituated to salts of copper. A dog experimented upon by Meyerhardt in my laboratory vomited after consuming 1 *grm.* copper chloride mixed with meat. But on the following days he ate without any symptoms 0·1, then 0·2, 0·5, 1, 2, 2, 2 *grm.* Meyerhardt himself experienced some tendency to vomit the first time when he took, in solution, 10 *mgrm.* copper in the form of copper sulphate. He continued these 10 *mgrm.* doses without intermission for fifty days, and he then took daily 20 *mgrm.* for thirty days, likewise without intermission. Kant in a similar manner took for fifty-one days copper acetate, beginning with 5 *mgrm.*, and then increasing to 10, 15, 20, 25, and for the last eighteen days 30 *mgrm.* The last dose is almost equivalent to 0·1 *grm.* copper sulphate. He experienced no trace of indisposition.

Hermbstädt (Orfila, vol. i., p. 316) relates as a proof of habituation to copper, that in his youth he ate eagerly "kummest," a favourite Thuringian dish, consisting of cabbage which had passed into the acetic fermentation, and was then boiled in a copper kettle. But when he again partook of this dish, after twelve years' absence from home, he was attacked with the most violent cholera and vomiting, whilst his family, who partook of the same dish but had not been absent from home, were not affected.—This incident is capable of another interpretation. 100 *grm.* "sauerkraut" (a dish very similar to kummest) which in Hermbstädt's experiments occasioned colic, took up in the author's experiments, if preserved in copper vessels, in 24 hours only 2·88 *mgrm.*, and in 48 hours only 5·9 *mrgm.* of copper. Quantities of 30 to 100 *mgrm.* Cu are always inert if mixed with food.

the preparations were taken in a concentrated form as pills. Galippe gave daily to dogs ½ *grm.* the most different salts of copper without injury. What has been said hitherto of nervous disturbances, paralysis, &c., occasioned by copper, is so unconnected that we have no occasion to admit any causal connection, and for the present we may refer the affection to the joint presence of lead, or to other accidental causes (§ 482).

From the above the danger of a systematic poisoning by copper is extremely smaller than is generally assumed, *e.g.*, by Orfila.

Of demonstrable severe acute poisoning cases by copper, produced by its admixture with food, not a single one has come to my knowledge. The reports in literature refer either to poisonings by ptomaines or to quite different poisons. See K. B. Lehmann's work mentioned in the bibliography. The danger of chronic poisoning by preserved vegetables (§ 349), bread (§ 340), drinking-water (§ 201), or cheese (§ 521) has, according to what has been said, probably never existed. The French Conseil d'Hygiene formally permits the addition of copper to peas, &c., if it is declared, and if it does not exceed 40 *mgrm.* per litre.

The inhalation of copper-dust, bronze-dust, dust of copper acetate, as it occurs to workmen in certain manufactures, scarcely occasions serious disease. A reddening of the edge of the gums, and greenish spots on the teeth and the mucous membrane of the cheeks have been observed (Bailly, Chevallier, and Boys de Loury), but no other disturbances. At Fürth, the chief seat of the manufacture of bronze-colours, nothing is known of copper-poisoning (Von Kerchensteiner, Merkel).

ARSENIC.

§ 485. Arsenious acid [white arsenic (As_2O_3)] and arsenic acid (AsO_4H_3), and their alkaline salts, are readily soluble in water. Copper arsenite (Scheele's green $Cu_3As_2O_3 + 2H_2O$), mineral green, emerald green, and its double compound with copper acetate, Schweinfurt green, mitis green, Neuwied

green, mountain green, May green, Vienna green, &c., are soluble in acids. Realgar, AsS_2, varying in colour from reddish-yellow to orange-yellow, and orpiment, As_2S_3, of a gold-yellow colour, are insoluble in water and dilute acid, but soluble in weak alkalies (ammonium carbonate, and therefore in the intestinal canal). Orpiment generally contains also a proportion of arsenious acid. Concerning the presence of arsenic in earthy colours see § 491. Crude sulphuric acid often contains 1 *grm.* As_2O_3 per kilo. In crude hydrochloric acid there have been found even 6 *grm.* As_2O_3 per kilo. (G. Buchner, Prauss). All the soluble arsenic compounds are easily absorbed, and easily again eliminated.

Acute domestic poisonings with arsenic are tolerably rare, but they were formerly very common when Schweinfurt green and arsenical aniline colours were in use, *e.g.*, on sewing or wearing a green ball-dress, on applying strongly arsenical wall-papers (fatal poisoning of an upholsterer, *Journ. de Chim. Med.*, 1868), on the consumption of confectionery coloured with arsenical colours or arseniferous magenta, &c. 10 *mgrm.* As_2O_3 have been observed to be dangerous to life, and 100 *mgrm.* are certainly fatal. The type of acute poisoning commences with a feeling of thirst and burning in the throat, and then becomes very similar to an attack of cholera.

Chronic arsenical poisoning cases, especially from paper-hangings, have been, and still are, by no means rare occurrences. The prolonged daily ingestion of very small quantities, from 1 to 3 *mgrm.*, suffice evidently for severe poisoning. The symptoms of chronic arsenical poisoning are: catarrh of all the mucous membranes, especially of the conjunctiva of the eyes, ulceration of the nostrils, loss of hair, and cutaneous eruptions (eczema), increase of the liver and fatty degeneration, sometimes jaundice; after large doses of AsH_3 hæmoglobinuria has often been observed, along with faintness, vomiting, diarrhœa, a sweetish taste in the mouth, &c.

Arseniferous paper-hangings may exert a poisonous action in two manners: on the one hand, arseniferous dust

may become detached, especially if the colours are imperfectly fixed; secondly, in damp rooms hydrogen arsenide may be evolved under the influence of the acid generated on the decomposition of the paste and the size, and the simultaneously occurring processes of reduction (probably by moulds). This gas, even in the smallest quantities, is recognised by its garlic-like odour. A great number of serious poisoning cases have been recorded as occasioned by arsenical paper-hangings. Recently Rossbach (*Tod durch arsenhaltige Tapeten oder Vergiftung mit Phosphor*, Jena, 1890, with bibliography of the subject) has with great probability referred the death of some children to residence in rooms containing arsenic hydride.

Arseniferous hangings have had an injurious action even when pasted over with several layers of paper free from arsenic. In any case, arsenical paper-hangings are suspected more frequently than heretofore as having been the causes of illness (see, *e.g.*, Kirchgässner, *Viertelj. f. ger. Med.*, October 1868).

According to these observations compounds of arsenic should be absolutely banished from our houses; this condemnation falls in the first place upon the brilliant green colours, Scheele's green and Schweinfurt green (lamp-shades, window-blinds, paper-hangings, gratings for flower-pots, artificial flowers), the aniline colour prepared with arsenic (especially formerly), or with the cheap refuse colours.

There have been found, *e.g.*, green stuffs containing 1·5 arsenious acid in the square foot, playing-cards containing 5·4 *grm.* As_2O_3, paper-hangings with 1·7 *grm.* per square metre. Very recently B. Fischer again found at Breslau a number of wax tapers coloured with Schweinfurt green. In 100 *grm.* there were determined about 2 *grm.* of the poisonous pigment. In 1878, of six of the finest green colours in Vienna only one was found free from arsenic; the others contained quantities up to 2½ per cent. of arsenic. This is now no longer the case. Thus lately Oesterle, in sixteen samples of the aniline colours of commerce, obtained no arsenical reaction on using ½ *grm.* of each in the Marsh apparatus (*Chem. Zeit. Repert.*, 1890, p. 234).

The German legal prescriptions, § 458, suppress arsenic almost entirely, since they merely permit the use of arseni-

ferous mordants in dyeing and printing tissues, with the condition that the finished goods must contain no arsenical compound soluble in water, and in general not more than 2 *mgrm.* arsenic in 100 *scm.* of tissue. Unfortunately, in a succeeding paragraph a quantity of arsenic is permitted in dyes as an impurity, without any definite limit. Especially earthy ferruginous pigments often contain considerable quantities of arsenious acid; iron arsenite is certainly a sparingly soluble substance.

Dragendorff[1] pronounces a material harmless as to its percentage of arsenic, if 100 *scm.* of paper-hangings, or 200 *scm.* of tissue, do not contain more than from 0·05 to 0·06 *mgrm.* arsenious acid, but rich in arsenic if from 0·7 to 0·8 are contained in the same volume. He is therefore decidedly stricter in his demands than the evidently mild German law. Schmelck alleges that he has observed in Sweden attacks of illness produced by bed-quilts containing 0·2 *mgrm.* arsenic in 100 *scm.*

ANTIMONY.

§ 486. Metallic antimony (in type metal) is quite insoluble in dilute hydrochloric acid.

Colourless tartar-emetic (antimonyl-potassium tartrate $C_4H_4SbKO_7+\frac{1}{2}H_2O$) is easily soluble in water. Of late other salts of antimony have been used in dyeing in its place, *e.g.*, antimonyl potassium oxalate, antimony fluoride, antimony sulphate, &c. These antimony salts form insoluble compounds with the colouring substances which they fix, and if the work is correctly performed, the superfluous soluble salt is washed out again. The orange-coloured golden sulphide Sb_2S is insoluble in water, weak hydrochloric acid, and ammonium carbonate; it is sometimes added to caoutchouc articles on vulcanising. Antimonial cinnabar (Sb_2OS_2) is now scarcely in use; it is soluble in hydrochloric acid.

Antimonial compounds can scarcely come into action in

[1] Or he calls a material, on manipulating according to § 471, free from arsenic if no spot is produced in ten minutes.

Harmless as regards arsenic if in ten minutes there is no distinct spot, or only a slight indication.

Strongly arseniferous if after three minutes a spot of arsenic is produced quite opaque to the flame of a candle.

the household by way of the digestive organs. Tartar emetic has proved fatal in doses of 0·5 *grm.*; as an emetic it is given in repeated doses of 0·03 to 0·1 *grm.* Cases are known in which even 10 *mgrm.* produced violent emesis. Chronic poisonings have been produced experimentally by small doses; if from 1 to 10 *mgrm.* are taken daily for about a fortnight severe chronic illness is occasioned.

Of much greater hygienic importance is the action of tartar emetic by way of the skin, when it occasions eczema and inflammations of the skin. Such cases have been repeatedly known, occasioned by tissues from which the antimonial mordants have not been properly washed out.

Bischoff found in 100 *grm.* of yarn 14 *mgrm.* of antimony soluble in water, and from 36 to 310 *mgrm.* soluble in hydrochloric acid (*Repertorium für Anal. Chemie*, 1883, No. 20). Kayser found in 100 *scm.* of a red-brown lining cloth, which had occasioned eczema, 85 *mgrm.* of antimony soluble in water. It is generally assumed that only such compounds are harmful as are soluble in water. Forth has proved the harmlessness of antimony tannate by experiments on his own person (wearing stockings specially prepared).

The injuries to the skin thus occasioned may serve as entrances for pathogenic micro-organisms, and thus occasion "blood-poisoning." The Bavarian agreements propose the same demands for antimony in tissues as for arsenic.

TIN.

§ 487. Metallic tin is almost insoluble in distilled water and in spring water; also in solutions of common salt. In acetic acid and other organic acids it is slightly soluble, but readily soluble in hydrochloric acid.

From alloys of lead and tin both metals pass into solution in acetic acid at first; after some hours the tin precipitates most of the lead, whilst the proportion of tin slowly increases. The precipitated lead, as well as that in solution, is liable to occasion illness if mixed with food.

The soluble salts of tin used in dyeing, pink-salts ($SnCl_2 + NH_4Cl$), sodium stannate (SnO_3Na_2), and sodium stannite

($SnO + NaOH$),[1] can scarcely occasion injury in domestic life.

Metastannic acid (SnO_3H_2), stannic oxide (SnO_2), tin sulphide = mosaic gold (SnS_2), are quite insoluble in water and dilute acids. The tin in preserved vegetables is also found insoluble in acids.

Acute poisoning cases have not been hitherto traced with absolute certainty to compounds of tin met with in the household.

Notwithstanding the intense toxicity of the soluble compounds of tin, if injected subcutaneously, morbid phenomena can be occasioned by way of the stomach only by doses so large as do not readily occur in domestic life. The absorption is very slight. After taking 0·5 *grm.* of tin in the form of preserved food, Ungar and Bodländer found only 4 *mgrm.* of tin in the urine, and no morbid symptoms whatever; but they allege having an acute case of poisoning in man with tin by preserved asparagus. Similar cases have been reported from England. Preserved cherries contained 0·67 per cent. tin malate (abstract in *Viertelj. in d. Fortschritte auf dem Gebiete der Nahrungsmittel*, 1890, p. 227). And from Holland, where 270 soldiers had eaten meat and salad from tin cans (*Chem. Zeitung*, xv., 1891, p. 564). Several similar cases have recently become known.

It has already been intimated (see § 484, Copper) that such cases of acute poisoning with tin excite in me the suspicion of poisoning with a ptomaine.

Chronic poisonings are scarcely to be apprehended. Ungar and Bodländer have produced in dogs, along with disturbances of digestion, grave affections of the spinal cord in the course of more than a year. They gave a dog weighing 7½ *kilos.* at first 0·01 to 0·12, and finally 0·4, 0·6, and 0·8 *grm.* of tin in the state of soluble sodium stannite. In another case, 0·02 to 0·2 and 0·6 of stannous chloride were admitted for the same length of time. A chronic affection in man by the abundant use of tinned foods is conceivable only if—what is certainly possible, but quite unproven—the susceptibility of man to tin is much greater than that of the dog.

ZINC.

§ 488. Metallic zinc, like lead, is somewhat soluble in water with the co-operation of free carbonic acid, but readily soluble in organic and inorganic acids. Dilute acids dissolve zinc-white (zinc-oxide, ZnO), zinc-yellow (zinc-chromate,

[1] Tin-crystals (stannous chloride $SnCl_2 + 2H_2O$) are used on a large scale in dyeing. Sodium stannite is rarely used in England.—*Editor.*

$ZnCrO_4$), and lithopone [a white powder formed by mixing zinc sulphate and barium sulphide = ZnS + ZnO + $BaSO_4$, used for colouring walls].

Acute Poisoning.—As far as observations are available, what has been said concerning copper holds good here qualitatively and quantitatively. Zinc sulphate is used as an emetic, and large doses (several grammes) have at times occasioned severe illness and even death. Zinc oxide is said to be bearable by grammes without injury, but if accidentally mixed with confectionery it has occasioned vomiting and diarrhœa (*Zeit. des allg. österr. Apothekervereins*, vol. xvi. 1878, p. 407).

Inflammation of the skin has been occasioned by wearing paper collars containing zinc oxide. Persons have been known in whom mild zinc ointment produces inflammation of the skin.

Chronic poisoning by the ingestion of small doses (up to 10 *mgrm.*) does not seem to occur. Aarlandt and Mylius report that in the districts where zinc blende is mined zinciferous waters are in many cases universally drunk without injury, so, *e.g.*, at Tuttendorf, water containing 7 *mgrm.* zinc per litre has been in use for more than a century (*Correpondenzblatt des Ver. Anal. Chem.*, 1879, Nos. 2 and 3). In the north of France milk is always preserved in zinc pails, and never occasions poisoning. In human organs, especially in the liver, there are often found considerable quantities of zinc, though no symptoms of zinc poisoning have occurred, and no medical treatment has been required. These facts are connected with the wide distribution of zinc in articles of food.

If larger doses (decigrammes or upwards) are introduced into the stomach for some time (in medicines), chronic disturbances of digestion may occur with their consequences (cachexia), but authorities are agreed that severe danger to health can scarcely arise; speedy recovery generally ensues after the digestion has been improved by the elimination of the zinc.

Some observers speak also of nervous disturbances which

occur in zinc workers after about ten years, *e.g.*, resembling *Tabes dorsalis* (Schlokow). Unquestionable observations on chronic nervous affections, similar to lead poisoning, have not been made known. They are at least much rarer than from lead. Tracinski considers the ascription of the diseases of zinc smelters to zinc as not sufficiently demonstrated, and calls attention to lead, cadmium, arsenic, carbon monoxide, sulphur, and carbon dioxides, which come simultaneously into play (*Viertelj. für öff. Gesundheitspflege*, 1888, p. 59).

Concerning the "casting-fever" of zinc and brass workers from inhaling the fumes of zinc (?) or zinc oxide, see Hirt (*Krankheiten der Arbeiter*, i. 85, ii. 165, iii. 82).

According to Tracinski the "casting-fever" is entirely absent at the zinc works.

NICKEL.

§ 489. Only metallic nickel and the salts formed from it by the acids used in the household possess hygienic interest.

According to Rhode, 500 *cc.* of 2 or 4 per cent. lactic, acetic, nitric, or tartaric acid, on standing for twenty-four hours in a basin of pure nickel or nickelised brass, &c., take up about from 25 to 35 *mgrm.* of nickel. In three hours, at the temperature of ebullition, there are taken up from 12 to 30 *mgrm.*; a 4 per cent. acid does not dissolve an importantly greater quantity than one at 2 per cent. Butyric acid attacks nickel more slightly. According to Laborde and Riche solutions of alkaline carbonates also take up a little nickel.

Domestic poisonings with nickel have not been hitherto observed. Rhode has used nothing but nickel vessels in his house for five years. Evidently even the more soluble salts of nickel are not readily absorbed, or they are promptly eliminated by way of the liver and the bowel. About ½ *grm.* of nickel sulphate, given daily to powerful dogs, occasioned neither acute nor chronic affections. See Jung, H. Schulz, and Geerkens, Laborde and Riche. Very large doses act about similarly to the salts of copper. The hygienic decision must for the present agree with that given on copper.

CHROME.

§ 490. Chrome yellow ($PbCrO_4$) and chrome red ($PbCrO_4 + PbO$) and barytes yellow ($BaCrO_4$) are insoluble in water, but soluble in dilute acids. The case is the same with zinc yellow ($ZnCrO_4$), which usually contains potassium chromate, and gives it up in water. Chrome green ($Cr_2O_3 + 2H_2O$) =

Guignet's green, or permanent green, is quite insoluble. It is a dark green colour, which is rendered lighter and of a bluish-grey by an admixture of barium sulphate. Or it is changed to a bright green by the addition of any of the chrome yellows enumerated above (Victoria green, permanent green, oil green, Nürnberg green, zinc green).

Guignet's green is harmless; the compounds of chromium oxide are altogether very slightly poisonous. The chromates may occasion lead, zinc, or barium poisoning, in addition to the effects of chromic acid. Hitherto only chromate of lead has been closely studied (§ 483). Concerning the other substances we can only say that zinc and barium chromates must be poisonous. Potassium chromate and chromic acid are very poisonous.

ALUMINA.[1]

§ 490*a*. Alum, aluminium chloride, and sulphate are easily soluble in water. They are used in dyeing, but in the course of the processes they are almost invariably changed into insoluble compounds (alumina, coloured lakes), which have no toxicological importance. Concerning alum in bread, see § 340. Wibmer took by degrees in 1½ days 3·65 *grm.* alum dissolved in 350 *grm.* water. The result was some constipation (*Repertorium der Pharmacie von Buchner*, 1831, vol. 39).

The various blue, green, &c., ultramarines are compounds of alumina, potassa, silica, and sulphur of unknown constitution, and varying composition. They evolve sulphuretted hydrogen in contact with acids, but in the doses in which they may be introduced into the human system in domestic life they do not involve appreciable hurtfulness.

COBALT, IRON, URANIUM, CADMIUM, SILVER, GOLD.

§ 491. Household poisonings by these metals are scarcely known, though some of them are very poisonous if they are

[1] Recent researches on the use of aluminium vessels in cookery agree in showing that they are not open to any hygienic objection. Plagge and Lubbin, *Veröffentlich aus dem Gebiete der Militärsanitätswesen*. Heft III. 1893.

artificially introduced into the body in suitable compounds. Here we must refer to the text-books of toxicology. But danger is scarcely possible in the following forms, almost the only states in which they occur in domestic life.

Cobalt: Cobalt silicate = SiO_3Co = smalts. Cobaltous oxide, stannous oxide = $CoO + SnO$ = cœruleum. Cobalt oxide, aluminium oxide = $Al_2O_3 . Co_2O_3$ = Thenard's blue = cobalt ultramarine. Cobalt oxide, zinc oxide = $Co_2O_3 + ZnO$ = Rinmann's green = green vermilion.

Cobalt scarcely meets with practical applications in any other state.

Iron in its ordinary forms may be regarded as harmless. They are: Metallic iron and steel, oxide of iron = Fe_2O_3 = English red = *caput mortuum*, mixtures of iron oxide, iron hydroxide, and iron carbonate as rust; the ferric salt of hydroferricyanic acid = $(FeCy_6)_3Fe_4$ = Paris blue, Berlin blue, Prussian blue. The ferrous salt of hydroferrocyanic acid = $Fe_2Cy_{12}Fe_3$ = Turnbull's blue.

As little injurious are the compounds of iron formed in the preparation of food, iron salts of the acids of fruits, of milk, of tannin, &c.

The yellow, brown, and red earth colours (ochres, terra di Sienna, &c.), which consist of ferric oxide and carbonate, are *per se* quite harmless, but they sometimes contain quantities of arsenic which are not unimportant. Iron arseniate is insoluble. Iron arsenite is soluble only if heated with concentrated acids.

Silver and Gold.—When pure, or in their usual alloys with copper, they are unimportant, as they are never dissolved in quantities to prove injurious.

Cadmium.—Is used only as cadmium sulphide, CdS, a pigment insoluble in water, dilute acids, and alkalies. According to Marmé it is harmless if given to animals in large doses. Soluble salts of cadmium are very poisonous.

Uranium.—Used at present only for the production of yellow colours in glass, porcelain, and enamels. Its intense toxicity, discovered by Kobert, will not readily have opportunities for development.

BARIUM.

§ 492. Barium chloride is easily soluble in water; the carbonate dissolves in dilute acids, and the chromate (barium yellow) in hydrochloric acid, but not in acetic acid. Barium sulphate (heavy spar, blanc fixe, permanent white) is quite insoluble. It plays an important part in the manufacture of paper-hangings and coloured papers, as a harmless, unchangeable body colour.

On acute barium poisoning, see § 340. Chronic poisonings have not been hitherto observed.

II. *ORGANIC SUBSTANCES.*

A. Examination for Organic Substances.

§ 493. As far as colourless organic substances are of especial hygienic importance, they have been considered in previous chapters; other important substances of this kind do not occur among articles of common use.[1] On the other hand, the organic colouring-matters concern hygiene to a somewhat high degree.

Among the many vegetable colouring-matters and the few animal substances in practical use, gamboge (the inspissated milky juice of *Hebradodendron cochinensis*) employed as a yellow pigment, is the only one known as a poison. The Swiss chemists prohibit also berberine (*Chemiker Zeitung*, 1891, No. 80).

On the other hand, among the hundreds of coal-tar colours which have come into use, some possess great importance, either by the frequency of their employment, their great toxicity, or their demonstrated harmlessness.

The presence of an organic colouring-matter is rendered probable in general by the circumstance that the reactions for inorganic coloured compounds fail, if, *e.g.*, the ash shows no constituent which may have occasioned the colour, such as chrome, lead, copper, &c. But frequently, in spite of the presence of such elements, we may often have before us organic colours fixed by means of metallic mordants. Organic colouring-matters, in contrast to those of inorganic nature, are often soluble not only in water, but also in

[1] It is, perhaps, necessary to mention oxalic acid, which occasionally proves poisonous by being confounded with other white powders, and is often very carelessly used as a cleansing agent. It is recognised by the white precipitate which it gives with solutions of calcium chloride of a neutral or an alkaline reaction (calcium oxalate), and by its property of very quickly decolorising solutions of permanganate in presence of sulphuric acid (§ 197). Of course all the methods for the removal of organic matter destroy also oxalic acid (§ 461). If there occurs an oxalate insoluble in water, it must be dissolved in dilute hydrochloric acid, adding afterwards calcium chloride and ammonia. For the detection of phenol see Dragendorff (Bibliography).

alcohol, ether, petroleum-ether, chloroform. Others dissolve in water or alcohol on the addition of a little acid or alkali, and show, on the addition of acid or alkali, very striking changes of colour, such as scarcely occur in inorganic compounds. It is recommended to prepare extracts with the above-mentioned solvents, and to place them (after concentration if requisite) in white porcelain capsules or large watch-glasses set on a white support, adding different reagents, the most important of which are: concentrated hydrochloric acid, concentrated sulphuric acid (with a subsequent addition of water), soda-lye. It may also be important to show whether the colouring-matter discharged by stannous chloride in an aqueous solution containing hydrochloric acid is decolorised (reduced), which is the case with almost all the azo-dyes now so largely in use.

The production of reactions by laying dyed swatches in the reagents leads often to more uncertain results, as the colours are often mixtures, and the reactions appear distinctly only with the pure colours. If we have to examine powder-colours, we may obtain an insight into the purity or the unitary character of the colouring-matter by scattering a very little of the powder upon wet filter-paper, and then upon concentrated sulphuric acid, observing the character of the halos which form around each particle of the powder. Tinctorial chemists separate solutions of mixed colouring-matters by fractionated introduction of wool or silk, and comparing the shades obtained each time. See also—

Goppelsröder. *Capillar Analyse.*

J. W. Slater. "Manual of Colours and Dyewares." London. Lockwoods. 1882. 2nd edit.

It had been my intention to give criteria for the recognition of the most important, and especially of the poisonous dyewares. But I have abandoned this intention, as, after a close investigation, I must dissuade the physician from making experiments in order to detect a given colouring-matter, especially when it occurs not as a pure powder-colour, but only as a dyed specimen. The number of the artificial organic colours now in use exceeds 300, and those of

them which are poisonous are generally not characterised by such reactions that their mention here would be useful without enumerating the numerous substances which are either decidedly harmless, or whose physiological action is unknown. These substances, on account of the similarity of their reactions, must come in question in the differential diagnosis. Even thorough chemists—if not quite specially engaged with tinctorial chemistry—though in possession of the best and most recent works on the subject, and of numerous comparative colours, regard the determination of an unknown colour submitted to them as generally a very difficult problem, and often as one not to be solved with certainty. An uncertain determination is generally useless for a decision.

I must, therefore, content myself with referring to the bibliography of the subject, endeavouring to treat the alleged results with great scepticism. When an organic colouring-matter is said to have exerted a poisonous action, we must never forget to test the suspected substance for arsenic and antimony, as well as for other inorganic poisons. (See *Decision.*) Experiments on animals should be made upon dogs, or especially upon cats, rather than upon rabbits. (See § 95.)

B. Decision on Organic Substances,[1] especially Coal-Tar Colours.

§ 494. The hygienic signification of the tar-colours has been hitherto very variously estimated. When the intensely toxic action of the first, crude, often intensely arsenical,

[1] Along with the coal-tar colours we may here mention gamboge and oxalic acid.

Gamboge in doses of 0·1 to 0·2 *grm.* is a drastic purgative which occasionally produces other unpleasant effects (violent vomiting, irritation of the kidneys), and in larger doses it may prove fatal. Sonnenschein reports a case of death in a man from 0·37 *grm.*

Oxalic acid has proved fatal in 5 *grm.* doses, quantities of 45 *grm.* have been endured. The action is partly that of ordinary acid-poisoning (corrosion, hæmatemesis, and collapse); partly in subsequent stages, cerebral, with convulsions and paralysis. Anuria and glykosuria are frequent.

colours had been observed, we were disposed to judge the tar-colours very severely; when it was afterwards found out that the impurities had been the chief cause of the injuries to health, there followed a period in which no coal-tar colour was recognised as poisonous in a pure state (Eulenberg and Vohl, 1870). Subsequent research, however, has made known a series of tar-colours which possess, in fact, considerable toxicity. There are already some cases known—not very many—in which severe and even deadly poisonings have been occasioned by pure colouring-matters. At the same time there still exist the possibilities described by Eulenburg and Vohl (*Vierteljahrsschrift für gerichtliche Mediz.*, 1870), whereby harmless colours may become injurious; but the realisation of these possibilities has become decidedly rarer with the changes and improvements in technical chemistry.

1. Colours may be contaminated by means of poisonous raw materials (aniline, phenol, &c.).

2. Oxidising agents which ought to have been washed out have been left behind from negligence, *e.g.*, arsenic acid, mercuric and mercurous nitrates, mercuric chloride, tin and zinc chlorides, antimony oxide and chloride, lead peroxide.

There was especial danger in the use of the richly arseniferous residual colours, waste colours.[1]

3. Harmless colour bases are combined, not with harmless acids, like the acetic, but the poisonous arsenious or picric acid:

e.g., Aniline-green picrate = iodine-green.
Rosaniline picrate = mauvaniline (orange).[2]

4. The cloth is previously treated with poisonous mordants which form with the bases upon the fibre sparingly soluble lake colours, *e.g.*, tartar emetic, arsenic acid, &c. From negligence the excess of soluble mordant is left in the fibre.

Toxic actions of tar-colours may occur, especially in two ways:

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[1] The waste from the Medlock process for making magenta is largely used for killing vermin, under the name of "London purple."—*Editor.*

[2] Neither of these colours can be called a picrate. Picric acid is often added to aniline greens in the dye-bath, if a more yellow tone is desired.—*Editor.*

1. By the consumption of coloured foods.
2. By the wearing of dyed clothing.

§ 495. The question whether dyed tissues, free from poisonous antimonial or arsenical mordants, may produce affections of the skin seems decided, at least, for picric acid. R. v. Hösslin (*Münch. med. Wochenschrift*, 1888, p. 637) describes an intense inflammation of the skin of the feet, with the formation of small vesicles and a strong yellow coloration in a man who wore shoes dyed with picric acid, along with stockings which were too thin. The colouring of the shoes was so intense that colouring-matter could be distinctly wiped off with a wet finger.

The question is less definite for the orange or red colours which are often accused. Corallin (substances containing rosolic acid), though accused by Tardieu and Roussin, has been proved by Landin, Babault, Bourguignon, and Weikert (1869) to be perfectly harmless when pure. Hence the former complaints must be referred to an impure material (arsenical mordant?). Sell has met with corallin which contained from its preparation an admixture of free phenol, by which the formation of vesicles might easily be explained. Aniline orange (Victoria yellow) has been especially often accused as the cause of skin affections. Crookes has admitted that the pure colouring-matter is the injurious principle, which is very possible, in view of its intimate connection with picric acid. Experiments also prove that striped stockings occasioned vesicles only where the coloured parts came in contact with the skin. To explain the striking fact that all men are not equally sensitive to aniline orange, Crookes refers to the unequally basic reaction of the sweat; alkalies are able to dissolve aniline orange, but water is not[1] (*Pharm. Journal*, 1868, October).

Whether or no Crookes has found the right explanation, it is plain that the skin of different men reacts very

[1] Compare notice, § 495A, on safranine and eosine. Weyl observed a case where new indigo-blue stockings, which had not been perfectly freed from sulphuric acid by washing, occasioned irritation of the skin (*Berlin med. Gesell. Sitzung*, 22,1889).

differently with chemical agents. See Von Sehlen, *Centralblatt für Bakt.*, vol. viii., p. 92.

§ 495A. I give now a list of those coal-tar colours on the harmlessness or toxicity of which we have definite information. Unfortunately the majority of the observations have only been made on dogs and rabbits, and the meritorious work of Weyl, from which I chiefly derive the following observations, has only appeared in part.

I call the substances injurious which, if given daily to a strong dog in doses of several centigrammes, occasion a disturbance of health either immediately or after a few repetitions. On the contrary, the colours which, when given for weeks in doses of 1 *grm.* or several grammes, are tolerated without disturbance, or only with unimportant symptoms in the intestinal canal, or with slight transient albuminuria, are pronounced harmless. We must not forget that even a few milligrammes of the coal-tar dyes colour very intensely, and that hardly more than a few milligrammes, or at most centigrammes, can find their way into the human stomach, even when very carelessly used, *e.g.*, by children. In extremely large doses, of course, many substances—*e.g.*, all our spices—are injurious.

Austria has, by the law of May 1, 1886, excluded all the coal-tar dyes (and rosolic acid) from use in colouring food and articles of consumption.

YELLOW COLOURING-MATTERS.

A. Harmless or Slightly Poisonous.

Naphthol yellow S. (acid yellow S., fast yellow, aniline yellow, succinine, sulphur yellow, citronine, jaune nouveau, jaune solide). From 2 to 4 *grm.* occasion in man colic and diarrhœa. Dogs scarcely affected by large doses. Said to be used in Algeria for colouring vermicelli.

Fast yellow R. (acid yellow R., yellow W.), Cazeneuve.

Brilliant yellow. Very large doses harmless to the dog.

Orange I. (α-Naphthol orange, Tropaeoline OOONI).

Bismarck brown. Slightly poisonous. 0·35 *grm.* per kilogramme cause albuminuria and vomiting in dogs; increased doses occasion no more injury. Small doses, 0·045 per kilogramme, quite harmless.

Soudan I. In very large doses (5 *grm.* daily) it produced slight albuminuria in a large dog.

Ponceau 4 G. B. (croceine orange, brilliant orange). Large doses not toxic to the dog.

Chrysoidine. Dog weighing 9·5 *kilos.* received 1 *grm.* daily for a month. Merely slight loss of weight and presence of albumen in the urine. Larger doses (10 *grm.* at once) occasion more severe albuminuria. Blaschko observed in some workmen severe dermatitis, alleged to be occasioned by this dye, but not in others.

Azarine. Dog weighing 10 *kilos.* took 20 *grm.* in twenty days. Only slight albuminuria.

Fast brown. Dog of 5·6 *kilos.* consumed daily for a month 2 *grm.* colouring-matter. Attacked with slight but persistent diarrhœa.

Chrysamine R. Large doses occasion slight albuminuria in the dog.

Butter yellow (dimethylamidoazo benzol). Harmless to rabbits, according to Weyl.

B. Poisonous.

Picric acid. Toxicity considerable, especially for persons in feeble health, though it has been exaggerated. From 0·6 to 0·9 potassium picrate has often been tolerated by man for a long time; was at one time used as a medicine. Very small doses occasion a yellow coloration of the skin and conjunctiva.

Saffron substitute (gold yellow, Victoria yellow, Victoria orange, aniline orange = potassium or ammonium salt of a dinitrocresol). Very poisonous. 0·050 per kilogramme, administered by way of the stomach, killed dogs with violent emesis, dyspnœa, and repeated cramps. A fatal case has occurred in a human subject by 4½ *grm.* administered instead of saffron to effect abortion.

Martius yellow (naphthol yellow, Manchester yellow, saffron yellow, jaune d'or, dinitronaphthol.) Strong poison. 0·14 *grm.* per kilogramme for two days killed a dog with emesis, violent thirst, rise of temperature, and albuminuria.

Aurantia (Imperial yellow). A Basle specimen was found poisonous by Gnehm. Others found Berlin specimens harmless. Weyl could not test their substance from want of material.

Orange II. (gold orange, β-naphthol orange, tropæoline 000 No. 2, mandarine, mandarine G extra, chrysaurine). 14 *grm.* given in three doses kill a dog of 10½ *kilos.* in nineteen days. Diarrhœa, loss of appetite, albuminous urine, ulceration of the bowel, fatty degeneration of liver and kidneys.

Metanil yellow (orange M. N.). 21 *grm.* of this dye killed a dog of 11¼ *kilos.* in twelve days. Vomiting, albuminuria, death without characteristic symptoms.

Safranine. Administered by way of the stomach. 2 *grm.* daily harmless: on the prolonged use of large doses it produces diarrhœa and cachexy; 0·05 *grm.* per kilogramme killed a dog if injected sub-

cutaneously (Weyl, *Zeit. f. Hygiene*, 1889, viii. 35). Weyl observed affections of the skin from a vest lining dyed with safranine.[1]

REDS.

Rouge soluble (azorubine S, fast red C, crimson). Harmless.

Rouge pourpre (new coccine, brilliant ponceau, cochineal red D, fast red D, Bordeaux S, amaranth, azoacid rubine 2 B). Harmless.

Bordeaux B. Fast red B. Harmless.

Ponceau R. (ponceau 2 R, xylidine red, xylidine ponceau). Harmless.

Metanitro azotine. 1 to 2 *grm.* daily harmless to a large dog.

Orchil substitute (naphthion red). 24 *grm.* were given in a month to a dog weighing 4·5 *kilos.* without injury.

Congo red. Very large doses occasioned merely slight albuminuria.

Magenta (aniline red, rubine, roseine, fuchsine). Impure magentas occur in trade also as maroon, garnet, geranium, cerise; is perfectly harmless. Men tolerate 0·5 *grm.* daily for a long time; 50 *mgrm.* daily were given for five weeks without effect. 20 *grm.* have been given to dogs at once without injury.

Acid magenta (rubine S, acid rubine), the sodium salt of the sulphonic acid of magenta, is to be regarded similarly.

Coralline, Peonine, Rosolic Acid, see § 495. Pure coralline was found harmless by Weikert if ingested along with food.

Eosine, Erythrosine (and a series of closely allied derivatives of fluoresceine containing bromine and iodine are, according to Grandhomme, quite harmless to rabbits and to the men employed at the colour-works). Weyl observed a case in which an affection of the skin was occasioned by wearing a ribbon dyed with eosine—by the eosine?

GREEN.

Dinitrosoresorcine (dyes cotton green if mordanted with salts of iron: Resorcine green, Alsace green, solid green). Large doses occasion at most slight albuminuria in the dog.

Naphthol green. The same.

Acid green (Helvetia green), harmless according to Cazeneuve, is no longer in use.

Malachite green. Harmless (Grandhomme).

BLUE, VIOLET, AND BLACK.

Wool black. Very large doses merely occasion slight albuminuria.

Naphthol black. The same.

Azo blue. The same.

Water blue (China blue, marine blue), non-poisonous according to Cazeneuve; also pronounced harmless by Santrini, like water blue, black blue, and Nicholson blue (alkali blue).

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[1] Safranine must have been placed by accident among the yellows. It is a beautiful and peculiar rose dye.—*Editor.*

Victoria blue. Injurious according to Santrini; 10½ *grm.* fatal in twenty-two days to a dog weighing 5¼ *kilos.*

New blue. Injurious according to Santrini; 12·5 *grm.* in thirty days fatal to a dog weighing 4½ *kilos.* Persistent vomiting, salivation, extreme emaciation.

Gallocyanine. Included among the poisonous colours by Santrini. A dog weighing 5·4 *kilos.* remained healthy after the ingestion of 7·5 *grm.* in thirty days. On dissection incipient fatty degeneration in liver and kidneys.

Indigo extract. Harmless according to Santrini.

Induline (an extensive group of nearly allied colours, including Coupier's blue, fast blue B and R, acetine blue, nigrosine), are harmless according to Cazeneuve, but very poisonous according to Santrini.

Gentiana violet. 4·7 *grm.* taken by way of the mouth by a dog weighing 3 *kilos.* proved fatal in seven days; loss of appetite and diarrhœa. On dissection there was found incipient interstitial hepatitis and hyperæmia of kidneys (Santrini).

Methyl violet and its allies (dahlia, aniline blue [gentiana blue 6 B], seem quite harmless (Grandhomme, Stilling, Santrini), as also acid violet, according to Cazeneuve and Santrini.

Alizarine blue. Perfectly insoluble in water; according to Ehrlich practically harmless introduced by way of the stomach. **Alizarine blue S** (the sodium salt of the sulphonic acid of alizarine) is poisonous. 0·4 *grm.* per kilogramme is a fatal dose for cats, and about 1 *grm.* per *kilo.* for rabbits.

Cœruleine. Insoluble, harmless (Ehrlich).

Cœruleine S. Poisonous subcutaneously (Ehrlich).

Indophenol. Insoluble in water, occasions diarrhœa if ingested into the bowel in large quanities (Ehrlich). A dog weighing 3 *kilos.* received in thirty days 18 *grm. per os.* Remained in health. On dissection slight fatty degeneration of liver (Santrini).

Methylen blue. Rather poisonous; according to Kowalewsky (*Centralblatt f. die med. Wissen*, 1878, p. 209) cats easily tolerate the intervenous injection of 0·04 *grm.* in solution of sodium chloride. Ehrich and Lipmann gave inwardly for therapeutic purposes from 0·1 to 1·0 *grm.* of methylen blue without any injury (*Deut. Med. Wochenschrift*, 1890, No. 23).

Ethylen blue behaves in a similar manner.

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SECTION XIX.

POINTS OF VIEW FOR INVESTIGATING THE CAUSES OF AN EPIDEMIC.

§ 496. However satisfactory has been the increase of our knowledge concerning the exciters of a considerable number of infectious diseases during late years, our accurate acquaintance with the true causes of the occurrence of epidemics increases but slowly. Altogether, I may venture to say, scarcely one extensive epidemic has been hitherto fully and completely explained, so as to give no room for objections; no doubt some unexplained phenomenon has always remained. If statistics have rendered it probable that, *e.g.*, water or milk had conveyed the exciter of the infection, the direct recognition of the latter has generally been lacking. If the water, according to all the rules of logic, has been excluded as the conveyer of the infection, no other satisfactory explanation has been found to take its place. If a parallelism has been ascertained between the level of the ground-water and the movement of the disease, no one has been able to explain how these two facts are connected together. According to my conviction, we know at present a number of things concerning the causes of infectious diseases, but a clear understanding of the causes of epidemics is wanting—the bridges to join the bacteriological and the epidemiological phenomena are often wanting. Along with further bacteriological laboratory researches on the properties of the exciters of infection, unprejudiced, many-sided observations of epidemics are of great value, especially when they have taken place in small localities known in detail to the observer, or at least accessible to investigation.

Only we must not forget that good epidemiological observa-

tion must be commenced years *before* the epidemic, and must be continued yearly. The following scheme will explain the course which the investigations have to follow.

A. Plan of Investigation.

I. General Observations on the Scene of an Epidemic, its Inhabitants and the Meteorological Factors.

§ 497. 1. General character of the district. Geology, altitude, relations to water, character of the superficial strata, &c. Compare § 154.

2. The meteorological factors, according to the closest possible observations in detail, especially the temperature of the air and the soil, height of barometer, downfall, level of ground-water, percentage of carbonic acid in the ground-air, dependence of the level of ground-water on rainfall or on the height of the water of a river.

3. Hygienic arrangements of the district; state of dwellings, water supply, source of food (milk, meat, &c.); removal of refuse, washing linen, &c. Have there occurred extensive excavations, dredgings, &c.?

4. The relations of the life and traffic of the inhabitants (statistics of occupation, settled population, and intercourse with strangers), military and civil population, intercourse with neighbouring places, &c. (statistics of intercourse).

As far as the observations can be expressed by maps, plans, curves, &c., this should be done, as it will give a much more rapid insight than can be obtained from tables. (See § 140.)

II. Special Observations on the Persons Attacked, and their Conditions of Dwelling and Living.

§ 498. These observations are collected by means of printed schedules of questions, to be filled up by the physician attending the case. To facilitate a conspectus they may be printed upon papers of various colours, differing either according to sex or according to locality, but otherwise alike.

They must contain the following questions :—

1. PERSONALITY OF THE PATIENT.

Name, fore-name, sex, age, native place.[1]

2. ABODE.

Street, number of house.

Story, whether front or back of house.

In hotels, barracks, &c., number of rooms.

Since when has the patient lived in the dwelling in question, or where did he live recently, or whence has h come ?

3. CONDITION OF DWELLING.

Water-supply.

State of W.C., &c. ; is there any escape of sewage gas ?

Position of bedrooms.

Degree of cleanliness of house.

How many persons per room ?

Have cases of the same disease occurred previously in the same house ? If so, was it disinfected, and how ?

4. OCCUPATION.

Where did the patient chiefly remain of late, and where did he work, attend school, &c. ?

What can be ascertained concerning the conditions there, in the sense of questions 2 and 3 ?

5. NUTRITION.

Whence has milk been procured ? Have substances been consumed which seem connected with the present epidemic, *e.g.*, artificial mineral waters, &c. ?

Has the nutrition been good, medium, or insufficient ? If another standard for a good position in life is preferred, can the density of population serve as such ?

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[1] In Germany the "name" of a person is that of his family ; the "fore-name" is what in Britain is called the Christian name.—*Editor.*

Celli (*Central. f. Bakteriol.*, v. 159) and Hesse (*Zeit. f. Hygiene*, v.) have shown by methodical researches that a series of pathogenic microbia may multiply well, or at least may be maintained for some time upon many of our articles of food. The foods were sterilised in a steam-pot, inoculated with pure culture, and examined after various intervals of time. Meat, raw or boiled, boiled white of egg, and milk are excellent media for cultures. *Staphylococcus aureus* flourishes even upon strongly salted sausages. Typhus remains alive on the same substance at least for a month, whilst cholera dies in a few hours. Cheese is a poor medium for typhus, splenic fever, and staphylococcus, and for cholera it is no culture-medium at all. The bacilli of cholera, in contradistinction to typhus and staphylococcus, can multiply for 2½ months upon slices of apple and pear. Upon discs of melon the organisms in general died off rapidly.

6. INTERCOURSE.

Has direct personal contact occurred with sick persons, *e.g.*, attendance upon those attacked with illness?

Has there been indirect intercourse with the sick, *i.e.*, with persons engaged in attendance upon patients, or have the persons attacked come in contact with articles used or soiled by the sick, *e.g.*, linen?

7. MANNER OF INFECTION.

How, where, and whereby does the patient believe he has been attacked, or can he say on this point nothing definite?

Day when taken ill, or supposed day of infection, if such can be given.

8. SPECIAL STATEMENTS.

E.g., since the commencement of the epidemic the patient has drunk no unboiled water; patient has been engaged for weeks in disinfecting infected houses.

III. Bacteriological Observations.

§ 499. Occasionally, *e.g.*, in cholera, bacteriological examinations of the dejections may be necessary or desirable for the diagnosis.

Search for the exciting cause of the infection, as far as it is known, should be made in all places where it is to be expected for general or special reasons, *i.e.*, examination

of soil, air, water, ceilings, linen, milk, and possibly other foods. A main condition for success is very prompt and, as far as possible, multiplied investigation. A division of the duty among several inquirers will in most cases be requisite.

If the direct detection fails researches may still be desirable, *e.g.*, whether the supposed exciter of the infection can maintain itself or increase in a given water, and other biological studies.

B. Utilisation of the Observations.

§ 500. When the material of the enumeration papers is completed, it is utilised by arranging it successively according to the most different points of view. We may, *e.g.*, arrange the papers according to streets and quarters, or, again, according to altitudes, or to water-supply, &c., and thus quickly ascertain the prevalence of the disease under the most varied conditions. The results obtained are tabulated or plotted out graphically.

When in possession of all these results we may endeavour to answer the following questions:—

I. Whence is the epidemic originally derived? How are the first attacks connected with those in other places and among themselves? What was the route of introduction? Have men or inanimate objects effected the introduction?

II. What is the relation between the increase and decrease of the epidemic in general, or in its several chief foci, to the progress of the meteorological factors, and to the rise and fall of the ground-water (all shown graphically)?

III. Are the cases of the disease grouped locally in any perceptible manner, or are certain districts especially attacked?

a. If yes, what is the cause of this localisation, or what is the relation of the most severely visited places (streets, houses) to those which have escaped from the following points of view:—

1. Position in altitude or depth, in a hollow, on a steep declivity, on a high flat, &c.

2. Permeable or non-permeable subsoil, purity and moisture of soil.
3. Supply of drinking-water.
4. Drainage.
5. Supply of milk.
6. Density of population and degree of comfort. Isolation of the houses.
7. Occupations.
8. Intercourse with strangers.

b. If no, can any other regular factor be recognised in the occurrence of the attacks of the disease? *e.g.*,

1. Are certain ages attacked?
2. Are certain occupations attacked?
3. Can there be found among those attacked any common disposing cause (*e.g.*, insufficient nourishment)?

The questions under *b* must be considered, even if striking localisations of the disease are found to exist.

IV. As a supplement to the inquiry in how far the localities attacked are distinguished by any characteristic from those which have escaped, the following consideration may serve:—Do quarters or districts, provided with the same hygienic arrangements and exposed to the same danger, differ in the frequency of the attacks? Such considerations are especially needful if the studies described under III. seem to have revealed any regularity, *e.g.*, rendered it probable that a certain water-supply is to blame for the attacks. In such a case the following points have to be weighed:—

Are all the houses, streets, or town-quarters supplied with the water in question similarly attacked?

a. If this is the case have they possibly, besides the water-supply, such a similarity in their situation, inhabitants, degree of cleanliness, that the water is not necessarily the cause of the disease.

b. If this is not the case may the surprising fact that single public buildings, hospitals, &c., remained free from attack though supplied with the same water, be explained

by the supposition that the water was not drunk at all, or only after it had been boiled, &c.

All the results obtained in Section III. have to be tested with a similar scepticism; unfortunately such scepticism leads almost always to the unsatisfactory answer that a definite channel of infection cannot be demonstrated in this manner with absolute certainty.

V. Bacteriological results may be of decisive significance for a full explanation of the epidemic, but in order to reach full certainty it must be here logically demanded that the exciting cause must not have been present before and after the epidemic, as well as during its continuance.

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SECTION XX.

EXAMINATION OF AND DECISION ON DISINFECTIVE AGENTS AND DISINFECTIVE APPARATUS.

I. Chemical Disinfectants.

§ 501. All disinfectants are applied either in the gaseous state or in solution in water. It is the purpose of the investigation to determine how great the percentage of the air or the water can be to the disinfective agent, in order that it may effect its purpose in the time desired. Earlier experiments with chemical disinfectants have often yielded too favourable results not always in agreement with each other, since a number of the more minute experimental conditions have been discovered only of late years.

Four grades[1] of an unfavourable effect upon micro-organisms are conceivable, according to—

1. The growth is not disturbed, but the pathogenic, zymogenic, &c., functions are enfeebled. *Enfeeblement, Mitigation.*
2. The organisms can no longer multiply, but they are not killed. *Asepsis, Kolysepsis.*
3. The vegetative states of the micro-organisms are destroyed, but not the enduring forms (spores). *Antisepsis.*
4. The vegetative and spore forms are killed. *Sterilisation* or *Disinfection.*

An enfeeblement is intentionally produced only for strictly defined purposes (obtaining protective inoculative matters). We do not discriminate between 3 and 4. In general we wish to obtain by our operations complete disinfection.

For experiments in disinfection we use chiefly the bacilli and the spores of splenic fever, the bacilli of typhus,

[1] As the first indication of an attack we observe a retarded development when transferred to a good nutrient medium (heat, cold, and chemicals act in this manner).

the vibrios of cholera, and *Staphylococcus pyogenes aureus;* sometimes, also, if it is required to test the maximum performance, there are employed spores of certain saprophytes, *e.g.*, those of the hay bacillus, of *Mesentericus vulgatus*, of the spores of bacilli inhabiting garden soil.

Temperature exerts a twofold influence. On the one hand it strengthens the fungicide action of the antiseptics hitherto tried (Henle, Behring); secondly, it allows the bacteria more readily to overcome the inhibitive power of small quantities of disinfectants (Behring), the aseptic action is reduced, whilst the antiseptic property is heightened.

The disinfective action differs also in different nutrient media. Thus the bacilli of splenic fever, if suspended in water, are quickly destroyed at a concentration of 1:500,000; in broth at 1:40,000, and in blood-serum at 1 in 2000 (Behring).

Von Esmarch has shown that spores of splenic fever obtained from different cultures at different times possess very different resistance against chemical and thermic action (*Zeit. f. Hygiene*, v. 71). A great number of specimens were found perfectly dead on the fourth day in 5 per cent. carbolic water; others were still alive after sixteen to twenty-one days, and one even after forty-two days. The resistance against currents of steam varies in a similar manner. Every investigator, therefore, who tests a new disinfectant on the spores of splenic fever should state what is the resistance of the spores employed against carbolic acid. Or, preferably, as C. Fränkel mentions (*Zeit. f. Hygiene*, vi., pp. 524 and 525), the different powers of resistance are handed down as a racial peculiarity, only extremely resistant spores should be used for such experiments. Fränkel names the bacilli which remained alive in 5 per cent. carbolic acid for less than ten days, "feebly resistant"; those which remain alive from ten to twenty days, "medium resistant"; those which survive from twenty to forty days, "highly resistant"; and those which live for longer than forty days, "extremely resistant."

Disinfection by means of gases has proved unsatisfactory; sulphurous acid, chlorine, and bromine act only in very large doses and on prolonged application. On the technical details of these experiments, which for practical purposes do not need repetition, see *Mittheilungen aus dem k. Gesundheitsamt*, Proskauer on "Sulphurous Acid," vol. i. p. 234; Fischer and

Proskauer on "Chlorine and Bromine," vol. ii. p. 228; Buchner, *Centralblatt f. Bakteriologie*, 1887, vol. ii. No. 12.

On the other hand, the disinfectant power of liquids has had to be tested for practical purposes, and still every year some new disinfectants are introduced into commerce.

1. Determination of the Concentration which insures Asepsis.

§ 502. We prepare, *e.g.*, a 10 per cent. solution of the disinfectant, and add respectively 1, 0·5, 0·3, 0·1 *cc.* to each 10 *cc.* of liquid gelatine. The tubes then contain each 1 per cent., 0·5 per cent., 0·3 per cent. 0·1 per cent. of the disinfectant; we then make up plunge or smear cultures and plates with the microbe in question. The same experiment is then repeated, using broth in place of gelatine as a nutrient medium. We may also inoculate the disinfected nutrient medium with mere sporiferous material, which has been previously freed from all bacilli by heating to 70° for half-an-hour, and observe whether the spores develop to cultures.

Behring has given this examination the following practical form:—We take from the infected liquid nutrient medium to be tested, *e.g.*, serum, a drop, and enclose it with a little vaseline hanging in a port-object ground concave on the lower side of a cover-glass. Then known quantities of the disinfectant, larger and larger, are added by degrees to the nutrient medium, repeating the installation of a drop culture after every addition and vigorous shaking. After 24 or 2·24 hours' stay in the incubation stove we may satisfy ourselves by means of the microscope concerning the growth in the several drops.

2. Determination of the Concentration which insures Antisepsis.

§ 503. We cultivate the microbes in question in broth, filter before spores have been formed, and use the filtrate as in § 502, with certain quantities of the disinfectant of

known strength. The filtration is effected through asbestos, and its object is to remove clots of bacilli. From these tubes we take, after the expiry of 1 minute, 5 minutes, 10, 15, 30 minutes, and 1 hour, a small platinum loop of material, introduce each into 10 *cc.* of liquefied gelatine, and form plates. We thus obtain such results as the following:—x per cent. of the disinfectant kills in 20 minutes, y per cent. in 1 minute, &c. If we suspect that the trace of disinfectant conveyed in the loop may have simulated the destruction of the microbes by rendering growth in the gelatine impossible, we check the result by inoculation with fresh microbiferous material or gelatine, to which has been added a similar loop full of the liquid to be disinfected at the same degree of dilution.

It must not be forgotten that bacteria enfeebled by disinfective action are more sensitive to the presence of traces of disinfectant in a nutrient medium than fresh spores (Geppert).

The error of the simultaneous introduction of small quantities of disinfectives may be avoided if we infect larger quantities of broth; *e.g.*, 100 *cc.* instead of 10 *cc.* of gelatine, and then place the culture-flask in the incubation niche. On the one hand the quantity of disinfectant is thus enormously diluted, and on the other an optimum temperature is supplied to the bacteria (Behring). It must be urgently desired that this method should always be used as a check on the gelatine plates.

Cocci and bacilli without spores have been dried upon silk threads or bits of filter-paper in the exsiccator and examined like the sporiferous preparations (§ 504). This method does not seem to deserve recommendation.

Geppert has lately shown that frequently when an examination by culture experiments showed a destruction of the micro-organisms (spores of splenic fever), the simultaneous inoculation of animals proved fatal to the latter. Hence follows the necessity of checking the results obtained in culture experiments by experiments upon animals. Behring found the contrary.

3. Examination of the Sporicide Power.

§ 504. Sporiferous materials have hitherto been used dried on silk threads. (See for the preparation of such threads, § 74.) The silk threads are placed for a known time in capsules of water, to which definite quantities of the disinfectant have been added. The threads were then taken out, washed by shaking them in sterilised water, and pressed into a glass box lined with agar. It was then placed in the incubation-niche, and the growth or the germination, if it occurred, was observed.

The early experiments of Nägeli and H. Buchner have shown that under circumstances an impure result is obtained, when particles of the nutrient medium upon which the spores were cultivated envelop them on the silk thread and protect them against the action of the sporicide agent. The results then cause the effects of the disinfectant to appear too little favourable. Geppert has recently proved that an inverse error may occur; *e.g.*, silk threads absorb very rapidly so much solution of mercuric chloride that it cannot be removed by simply washing. The spores then, when introduced into gelatine, fail to germinate, not because they are dead, but because the surrounding gelatine is rendered aseptic by the mercuric chloride which diffuses into it.

We work, therefore, now generally with sporiferous *liquids*, *i.e.*, with a suspension in sterilised broth of a sporiferous "lawn" which has been cultivated upon agar. It is easily obtained by pouring a little broth upon an agar cultivation held in a sloping position, passing the needle lightly over the surface of the "lawn," and filtering the emulsion through glass wool. This liquid may then be treated exactly according to § 2.

More like the method with silk threads is a desiccation of the watery suspension on sterilised cover-glasses or pieces of platinum wire. These objects, after remaining for a time in the disinfective liquid, may be perfectly freed from any adhering traces of the disinfectant by a thorough

washing with water or alcohol. Ammonium sulphide and sulphuretted hydrogen have recently been used for removing mercuric chloride (Geppert).

§ 505. Along with these methods of investigation which form an indispensable basis for a decision upon and a comparison of the several means, experiments are necessary which belong intimately with hygienic practice. Thus experiments have to be made with actual soiled linen, with fæces artificially mixed with cholera bacilli, with the entire sputum of phthisical patients; in such experiments considerably larger quantities of the disinfectant are always found necessary than with pure cultures.

In order that a chemical disinfectant may be recommended to the general public for universal use, it must—

1. Produce quick sterilisation even when the agents of infection are mixed with large quantities of organic substances.

2. It must be cheap, easy to procure and to keep.

3. It must not be a strong poison. Properties are desirable such as a remarkable smell or an unpleasant taste, which may serve as a caution against its ingestion. Of course too intense an odour becomes an objection to its use.

4. Its action must be easily observed. This property is met with in acids and powerful alkalies; thus milk of lime added to a stool in such proportions as to turn red litmus-paper decidedly blue is sufficient, according to Pfuhl, in the course of an hour, for the certain disinfection of an added mixture of typhus and cholera bacilli.

5. The objects to be disinfected must be damaged as little as possible.

A disinfectant fulfilling all these requirements has not hitherto been discovered. Mercuric chloride along with acids, quicklime, chlorine, and preparations of phenol and cresol, contest among themselves for superiority.

The special requirements for surgical, &c., disinfectants cannot be here considered.

II. Disinfection by Heat.

§ 506. Disinfection by heat may be effected—

1. By ignition or combustion.
2. By boiling in water.
3. By dry hot air.
4. By steam.

1. Ignition can be endured without injury only by platinum; the other metals and articles of glass are easily injured. Hence this method plays a great part in the laboratory, but not in practice (§ 53). Worthless articles, such as old clothing, rags, straw from beds, toys, &c., are simply burnt in preference, in order to destroy any adhering micro-organisms.

2. Boiling in water or in a weak solution of soda is very practical for a number of articles, thus, *e.g.*, surgical instruments are most simply and certainly sterilised in this manner.

3. Dry hot air is now used only in special cases, since only temperatures (140°–150°) which already char vegetable tissues destroy the more resistent spores in a short time (30 minutes). Hot air is used in the laboratory for the disinfection (§ 53) of glass vessels, instruments, wadding, paper. In practice apparatus is no longer constructed for disinfection by hot air. Occasionally, however, a baker's oven, if its use can be obtained gratuitously, may serve, if not for the destruction of the spores of splenic fever, for killing the non-sporiferous bacteria of cholera, typhus, and diphtheria, and especially of animal vermin.

4. The method of practical disinfection now universally in use consists in the application of hot watery vapour. The simplest apparatus of this kind approximates closely to Koch's steam-pot (§ 53). The objects are left for a certain time in steam ascending from boiling water and escaping at an aperture above. (Disinfection in a current of steam.) If only so much steam enters as to replace that lost by condensation, we speak of disinfection by stagnant steam. There exist a series of apparatus (in contradistinction to those described in which the steam acts at the pressure of the

atmosphere) constructed for the use of steam at a tension of from $\frac{1}{20}$ to 2 atmospheres. In these apparatus, after the air has been expelled, the aperture for the exit of the steam is closed by a safety-valve, which allows a transitory escape of steam only when the desired tension is exceeded.

§ 507. If it is desired to obtain a steam-disinfecting apparatus, such as are now to be procured in many different designs and sizes at very different prices, from a large series of establishments, attention must be given to the following points. (According to E. von Esmarch, *Desinfections apparate und ihre Anwendung. Hyg. Rundschau*, 1891, No. 1.[1])

1. In general we prefer an apparatus without tension, or one not exceeding $\frac{1}{20}$ to $\frac{1}{10}$ atmosphere. Steam of a higher tension certainly acts more quickly, since the objects sooner reach a temperature of 100°. These advantages, however, are more than compensated by the disadvantage of the necessity for a more solid construction of the apparatus, of procuring a steam boiler and trustworthy heater. The steam is preferably allowed to enter from above, since the heavier cold air is thus easily expelled.

2. The apparatus are most conveniently made of iron coated with oil-colour. If high-pressure steam is used, the thickness of the sides must not be less than 3 *mm*. Apparatus of wood and stone are not to be recommended; if of wood they are certainly cheap but not durable, if of stone they are neither cheap nor durable, and they are very costly in use, on account of their great absorption of heat, unless kept in constant action. It is advisable to have the apparatus jacketed with some material which is a poor conductor of heat.

3. The shape has no fundamental importance. Horizontal cylinders, round or oval, are relatively cheap, but in them

[1] It is very important for the steam to be saturated. Non-saturated steam, though strongly heated, acts badly. A full steam-temperature exists in the objects to be disinfected only as far as water is condensed. The condensation zone moves forward towards the interior of the packages in a sharp line (Teuscher, Frosch, and Clarenbach).

the space is not so well utilisable; rectangular horizontal chests have the opposite qualities.

4. Apparatus for detached hospitals should not contain less than 2 *cm.* Larger hospitals and small towns require an apparatus of 5 *cm.* capacity, or two holding 2 *cm.* each. It is often very desirable to have a movable apparatus, such as are now manufactured in abundance.

5. The steam may be introduced either directly below or at the side. Apparatus (Thursfield) in which the water-boiler incloses the disinfecting space like a jacket permit of an inexpensive preliminary heating of the space. The steam is often obtained from a source which is already existing (*e.g.*, in manufactories).

6. Many apparatus admit of heating the disinfecting space independently of the entrance of steam by means of closed steam-worms. Thus before disinfection we may obtain a preliminary heating, and after it a desiccation of the objects.

Von Esmarch regards the preliminary and the subsequent heating, which extend the duration of the disinfective process to double the time (from 20 to 40 minutes), as not absolutely necessary, and as certainly to be dispensed with in time of epidemics, when the apparatus is in great requisition. However, bed feathers retain immediately when taken out from 3 to 5 per cent. of moisture, and merely fractions of a per cent. if dried. Inferior qualities are often rendered hard and lumpy by this retention of moisture. Good ventilation may also, however, approximately expel this residual moisture. As to the erection of the apparatus, we must consider—

7. The apparatus must be set up in a thoroughly ventilated room, as it will otherwise be rendered permanently damp.

8. If it is necessary to work regularly with a large apparatus, two rooms are necessary, one for the articles to be disinfected and one for those already disinfected. The apparatus is best placed so that it is fitted with the middle of its longitudinal diameter into the wall separating the two rooms. At each end there is a door. The articles to be disinfected are introduced through the door in the room for holding such articles, and those already disinfected are

emptied into the room for disinfected objects. There must be no other access from the one room to the other save through the apparatus.

In working the arrangement it is requisite that—

(1.) The articles to be disinfected must not receive any spots. Rust-spots will be avoided if all the metal baskets for containing the articles are carefully wrapped round with linen or flannel. Finer articles (body linen, light-coloured clothes, &c.) must be inclosed in linen bags as a protection against drops of condensed water. The firmness of the tissues does not suffer, but various tones of colour, impressed patterns, &c., disappear.

2. Old articles which have contracted a fusty smell must not be disinfected along with new clothing, &c., since the latter often take up the disagreeable smell.

§ 508. Strictly speaking the examination of the capability of a disinfecting apparatus may be effected in a twofold manner, either by means of the contact thermometer, or with cultivations of bacteria. It is preferable to use both these procedures simultaneously. If we wish to use the contact thermometer we place it in the midst of a thick bundle of blankets, such as they might be rolled up in practical disinfection.

If the temperature rises to 100° the circuit is closed and the signal-bell sounds. We then know what length of time is required until the temperature necessary for the destruction of the spores has been reached. From this time the articles must remain in the apparatus for about twenty minutes. For thoroughgoing experiments several contact thermometers are naturally used at once, in order to obtain an accurate representation of the distribution of the temperature in space. Simple thermometers for reading off, and maximum thermometers to be read off after the experiment, do good service. The temperature of the steam entering or escaping, and in apparatus working at high pressure, the indications of the manometer are useful as checks.

If we have no contact-thermometer at disposal—which ought to be attached to every disinfection apparatus—we introduce into the interior of a roll of blankets slices of potato, with sporiferous cultures of splenic fever, small packets of sporiferous garden soil, wrapped up in sterilised paper, and withdraw them from the apparatus in fixed successive experiments, *i.e.*, after 20, 25, 30, 35, and 40 minutes from the beginning of the appearance of steam, and we examine the vitality and the virulence of the heated bacteria by means of cultures and experiments on animals. In from thirty to forty minutes, after the appearance of steam, the resistant spores of splenic fever ought to be dead. It seems unjustifiable to declare an apparatus bad which does not quickly destroy the most resistant spores (hay-bacillus, bacilli from garden soil), for which high-pressure steam is needed.[1] We may regard it as certain that the unknown exciters of the diseases not as yet thoroughly ætiologically investigated (measles, scarlet fever, small-pox, &c.) will not be more resistant than the spores of splenic fever. If such resistant spores of splenic fever are destroyed in from thirty to forty-five minutes from the beginning of heating, if the cost of the apparatus is not too high, its construction substantial, and the consumption of fuel moderate, the apparatus may be recommended, always supposing that the articles to be disinfected leave the apparatus dry, without spots or other damage.

This is not the place to enter upon the reasons why the various apparatus act differently well, and cheaply; the biblographical indications give sufficient indications on this subject.

III. Mechanical Disinfection.

§ 509. It is sometimes possible simply to remove the micro-organisms without killing them. This principle comes especially into play in rubbing the walls with black bread, which has been found successful by Von Esmarch. It is easy to satisfy ourselves of the efficacy of this method after

[1] On the sensitiveness of various bacilli to heat see § 303 and § 53.

rubbing.[1] The ventilation of sick-rooms may also be regarded as mechanical disinfection, though its efficacy cannot be readily shown by experiment.

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[1] But what of the dust, some of which would certainly fly about, except the walls were decidedly damp.—*Editor.*

APPENDICES.

THE following pages supply all important advances relating to the subject of the present work which have been made during the progress of the translation, up to January 1st, 1893.

K. B. LEHMANN.

§ 47. Botkin greatly recommends Gram's method of rinsing the sections with aniline water after taking them out of the aniline-water gentiana-violet solution *before* introduction into iodised potassium iodide. Such preparations bear the subsequent treatment with alcohol much better (*Central. f. Bakt.*, xi. No. 8).

§ 60. Reinsch recommends nutrient albuminiferous media sterilised with ether in the cold (*Central. f. Bakt.*, xi. 30).

§ 65. On improvising in bacteriological work compare the noteworthy article by Von Esmarck (*Hygien. Rundschau*, ii. 653).

§ 79. Wassermann and Proskauer suspect that the toxalbumens are not albumenoid bodies, but merely substances precipitated along with albuminous bodies. Various authors also incline to this opinion.

§ 83. For further micrococci with *spontaneous movement* see *Central. f. Bakt.*, vi. 566; vii. 637; xii. 49. A Sarcina with spontaneous movement has also been discovered.

§ 83. On *Streptococcus longus* compare Behring (*Central. f. Bakt.*, xii. No. 6).

§ 83. Jordan has observed two cases of erysipelas occasioned by *Staphylococcus* (*Langenbeck's Archiv*, xlii., 1892).

§ 83. *Leuconostoc mesenterioides* grows upon nutrient media free from sugar, without membranaceous coatings, after the manner of a Streptococcus (Liesenberg and Zopf, *Central. f. Bakt.*, xii. 659).

§ 84. The typhus bacillus is still, as formerly, especially difficult to diagnose if mixed with other bacteria. Dunbar (*Zeit. f. Hygiene*, xiii.) has shown that all the methods hitherto recommended for obtaining typhus cultures by additions of acids, phenol, &c., in order to check the development of other bacteria, have only a very limited utility, since *Bac. coli communis*, which is never absent in the bowel, is still more resistant against injuries. Further, *Bac. coli communis* upon such

prepared media grows more similar to the typhus bacillus than otherwise. As *Bac. coli communis* has spontaneous motility, and presents flagella, we must use for a differential diagnosis, according to Dunbar in the first place the circumstances that (1) *Bac. coli communis* coagulates milk, which the typhus bacillus does not; (2) *Bac. coli communis* forms gas in ordinary bouillon, whilst the typhus bacillus does not.

Ferrati's results are quite similar (*Arch. f. Hygiene*, xvi. 1). Also Weyland, who compared the formation of CO_2 in broth by the typhus bacillus, in bouillon with that of a bacillus resembling that of typhus, observed in the former a much smaller quantity of CO_2 (*Arch. f. Hygiene*, xiv., part iv.).

§ 85. Arens discovered in my laboratory a method of detecting a few cholera spirilla in water. To 175 *cc.* of the suspected water he adds 25 *cc.* of Karlinski's pancreas broth (200 *grm.* ox-pancreas, 500 *cc.* distilled water, 20 *grm.* Witte's peptone) and 1 *cc.* of potassa-lye at 10 per cent. The whole is placed in the incubation niche. After from twenty-four to thirty-six hours a very thin greyish veil can be noticed on the surface of the liquid, consisting entirely of spirilla. To ascertain if the cholera spirilla are present in this veil, firstly pancreas bouillon, diluted with from eight to ten volumes of water, is infected with it, to test for indol, and secondly plates are made up with it, so as to get a pure culture of the spirillum.

By this means Arens was certain to find two cholera germs in 5 *cc.* of water, and almost certain to find one germ in 5 *cc.* Heim and Dahmen have published similar methods (*Central. f. Bakt.*, xii., pp. 353 and 620).

§ 85. On the morphology of the cholera bacilli compare Friedrich (*Arb. aus dem kais. Gesundheitsamt*, vol. viii.), and Douglas Cunningham ("Scientific Memoirs of Medical Officers of the Army of India," part vi., and *Arch. f. Hygiene*, xiv. 45).

§ 85. According to Gamaleia (*La Semaine Medicale*, 1892, No. 39), the dog is very susceptible to cholera.

§ 85. Concerning the behaviour of the cholera bacilli upon fruit, drinks, tobacco, bread, &c., compare *Bakt. Central.*, xii., pp. 755 and 913.

§ 86. Richard Pfeiffer describes the exciter of influenza as a fine bacillus, generally associated in pairs, and capable of being stained with carbolic magenta, but not by Gram's method.

The bacillus grows with certainty only if a little blood—preferably normal human blood—is rubbed down upon agar congealed in a slanting position, and mixed with $1\frac{1}{2}$ per cent. of sugar. A brood temperature is necessary. The culture is best obtained from a smear-preparation of the sputa of influenza-patients, diluted with broth free from germs. The colonies form small drops, clear as water, which reach their full growth in forty-eight hours, and (not confluent) die off

in from four to five days. These organisms are very readily killed by dryness (twenty to twenty-four hours), heat (five minutes at 66°). According to Pfeiffer the only animal susceptible to the disease is the ape. Pfeiffer and Beck (*Deutsch. med. Wochenschrift*, 1882, No. 21), Pfuhl (*Central. f. Bakt.*, xi., No. 13).

§ 86. A rather circumstantial but alleged excellent method for detecting the bacilli of tubercle in milk has been given by Tekewitsch (*Münch. med. Wochenschrift*, 1892, No. 5). Kitasato (*Zeit. f. Hygiene*, xi. 441) and Pastor (*Central. f. Bakt.*, xi., No. 8) give instructions for cultivating tubercle bacilli from human sputum.

§ 86. J. Forster has very carefully examined the resistance of the tubercle bacilli to heat, using very eligible methods.

At 55° they die in four hours (not in three).
At 60° „ „ one hour (not in three-quarters).
At 70° „ „ ten minutes.
At from 80° to 90° in five minutes.
At 95° in one minute.

Similar but rather lower resistances have been found by Bonhoff (*loc. cit.*, 1009; *Hygien. Rundschau*, ii. 869).

§ 86. Maffucci has described the bacillus of chicken cholera very thoroughly (*Zeit. f. Hygiene*, 1892, xi. 445).

§ 87. Klein (*Central. f. Bakt.*, x., No. 6) and Sanfelice (*Annal del inst. d'Igien di Roma*, vol. i., fasc. iv., 1892) describe an aërobic pseudo-œdema bacillus. The last work contains much interesting matter on anaërobic bacilli.

On Actinomycosis compare Woepf and Israel (*Virchow Archiv*, cxxvi. 11). Gruber describes a new pathogenic microbe of the group of Actinomyces: *Micromyces Hofmani* (*Arch. f. Hygiene*, xvi.).

§ 91. On the technics of the examination of the Hyphomycetes compare Unna (*Central. f. Bakt.*, 1892, No. 11). Unna now knows and describes nine exciters of favus (*Central. f. Bakt.*, xiii. 1).

§ 91. Roux, G., and Linossier, G., have made new investigations on the "soor" fungus, in which they show a kind of formation of chlamydospores. They dispute a connection with *Monilia candida* (*Arch. de Med. expérimentale*, 1890).

§ 93. Schottelius has described in a very careful study a peculiar organism which he considers as the exciter of foot-and-mouth disease, and which he names Streptocythen. This organism consists of globes of unequal size, grouped together in the form of a rake. The terminal members have an amœboid movement. Single globules possess a peculiar spontaneous motility. They are most readily stained according to Gram's method. They grow sparingly and slowly upon glycerine-agar and glycerine-broth in the shape of tender, almost translucent,

pearly-grey colonies. The transfer to animals has been hitherto unsuccessful (*Central. f. Bakt.*, xi., Nos. 2 and 4).

On Dysentery compare Councilman, W. P., "The Form of Dysenteria produced by *Amœba coli*" (*Journal of American Medical Association*, June 6, 1891). According to the researches of Maggiora there is also a flux (or form of flux) which has nothing in common with the dysentery amœbæ, but rather seems determined by a virulent form of *Bacillus coli communis*. Maggiora only once found amœbæ among 2000 patients from the province of Alessandria (*Central. f. Bakt.*, xi., Nos. 6 and 7).

In dysentery in South Japan Ogata never found amœbæ, but fine, short bacilli in pure cultures. They liquefied gelatine, and could be transferred to animals (*Central. f. Bakt.*, xi., Nos. 9 and 10).

§ 93. For the examination of the higher fungi are recommended: Ludwig, F. (*Lehrbuch der niederen Cryptogamen*, Stuttgart, 1892), and Von Tavel (*Vergleichende Morphologie der Pilze*, Jena, 1892).

In both these works the recent researches of Brefeld are placed in the foreground.

On the process of fermentation thorough information is found in A. Koch (*Jahresberichte über die Fortschritte in der Lehre von den Gährungs organismen*). Two yearly issues have appeared. Braunschweig. 1891 and 1892.

§ 135. In order to try if a solution of sodium thiosulphate is still good, it is mixed with iodine until the colour becomes slightly yellow, when on the addition of barium chloride no precipitate of barium sulphate should appear.

§ 149. Georg Buchner has instituted extended investigations on the proportion of CO_2 in the atmosphere (*Wollny's Forschungen auf den Gebiet der Agriculturphysik*, xv., Nos. 3 and 4), which supply comparative values useful to the hygienist.

§ 153. Winkler, Cl., *Lehrbuch der technischen Gasanalyse*. 2nd edit. 1892. Freiberg. Distinguished.

§ 183. For the detection of small quantities of N_2O_3 with IK-starch the lowest possible temperatures are recommended.

§ 191. G. Buchner (*Chem. Zeitung*, 1892, p. 1954) points out that in determining the hardness of water with soap the experiment should be made at 15°. Lower temperatures decrease the consumption of soap, and higher temperatures increase it very considerably.

§ 201. For the possibility but the great improbability of the occurrence of epidemics by drinking-water, evidence is given by the experiments of Schönwerth, who repeatedly infected a well with chicken-cholera, and allowed fowls to use the water (*Arch. f. Hygiene*, xv., part i.).

§ 203. A copious and recommendable book of reference is Ferdinand Fisher's *Das Wasser seine Verwendung, Reinigung, und Bertheilung mit Besonderer Berücksichtigung der gewerblichen Abwässer.* Second revised edition, Berlin, 1891.

§ 205. On the examination of Chamberland filters and similar appliances, compare *Central. f. Bakt.*, xii., Nos. 2, 3, 7, 8, and 18.

§ 213. Okada has shown (*Arch. f. Hygiene*, xiv. 364) that Kjeldahl's determination of nitrogen can be very conveniently used for a determination of carbon.

§ 227. The following simple recognition of boric acid deserves recommendation: The liquid in question is rendered alkaline, evaporated down, and incinerated. The ash is extracted with water, cautiously acidulated with *weak* hydrochloric acid, and reduced to dryness, laying in it a small slip of turmeric paper. The dry turmeric paper shows a cherry red colour, which if moistened with alkalies passes into a bluish green. Braud, *Chem. Zeitung Rep.*, 1892, p. 350.

§ 234. Tappeiner and Brandl found, in chemical dietetic experiments on the dog, that on the prolonged ingestion of doses of from 0·1 to 0·9 *grm.* sodium fluoride, stiffness of the position of the vertebral column gradually appeared. Much fluorine is stored up in the body, especially in the bones, as calcium fluoride. Hence sodium fluoride cannot by any means be regarded as an indifferent preservative agent (*Arch. f. experim. Path.*, xxviii.).

§ 239. Maljean distinguishes meat which has been frozen from normal meat by examining a little blood from the interior of the meat. Freezing deforms and decolourises the blood-corpuscles; the serum takes a dark colour. Despatch in manipulation is necessary (*Chem. Zeitung Rep.*, xvi. 133).

§ 247. *Distomum lanceolatum* has hitherto been observed only four times in man.

§ 248. On *Pentastomum denticulatum* see Ostertag (*Zeit. f. Fleisch- und Milch Hygiene*, ii. part iv.).

§ 249. On tuberculosis in the carnivora, compare Jensen (*Deutsche Zeit. f. Thier. Med.*, xvii. part iv.).

§ 256. Ostertag (*Zeit. f. Fleisch und Milch Hygiene*) takes a decided position against the too strict treatment of the flesh of cattle with localised tuberculosis, as often from 30 to 50 per cent., according to the result of trial inoculations, must be characterised as tuberculous. According to Röckl (*Arb. des k. Gesundheitsamts*, vii. parts ii. and iii.), the proportions are much more favourable.

Ostertag even pleads for the harmlessness of meat if there are found in the spleen, lungs, and liver, single (embolic), dry, old tubercular nodes, always supposing that the flesh is free (*Zeit. f. Fleisch und Milch Hygiene*, ii. part i.).

§ 256. Kastner, under the advice of Bollinger, has sought to explain the difference of his results (mentioned in the text) on the inoculation of guinea-pigs with the expressed muscular juice of tuberculous animals from those of Steinheil. Kastner's earlier experiments were made with the flesh of beasts suffering from the ordinary calcifying type of cattle tuberculosis. The recent experiments which gave chiefly positive results were made with the flesh of cattle, which contained casifying nodes (the ordinary form in man, rare in oxen).

§ 258. Segers describes chronic poisoning among the Fuegians by poisonous mussels. Cirrhosis of the liver is the most prominent symptom (*Semaine Medic.*, 1891, No. 54).

§ 266. On the proportion of saltpetre and common salt in salt meat, compare Nothwang (*Arch. f. Hygiene*, xvi. 122). The loss of albumen in salting is from 1·5 to 2 per cent. That of P_2O_5, 35 to 50 per cent. The nitrous acid found in the brine is explained by the reductive action of meat upon the saltpetre.

§ 267. On fish poisoning compare the interesting experimental studies of Fischel and Enoch (*Fortschritte der Medicin*, 1892, No. 8).

§ 267. Schlampp, *Die Fleischbeschau-Gesetzgebung in den sämmtlichen Bundesstaten des Deutschen Reichs.* Stuttgart. 1892.

§ 267. Compare Blanchard, *Sur les Végétaux Parasites non microbiens transmissibles des Animaux à l'Homme et réciproquement* (*Progress Medical*), 1892. (*Cent. f. Bakt.*, xii. 681.)

§ 275. According to Sir Charles Cameron the white colour of milk is occasioned not alone by fat but by caseine in a very fine state of division (*Chem. News*, 1892, p. 187).

§ 297. On the occurrence of amyloid substance (irregularly shaped particles turning blue with iodised potassium iodide in milk and dairy produce), compare J. Herz (*Chem. Zeit.*, 1892, p. 1594).

§ 297. On soapy milk see Herz (*Chem. Zeit. Repert.*, 1892, p. 34).

§ 298. Baum, on feeding young dogs with the milk of cattle which had consumed tartar emetic, observed no case of illness among them, and does not anticipate any in human beings.

§ 300. Guillebeau (*Landwirth, Jahrbuch*, iv. 27) publishes interesting studies on defects in milk and inflammation of the udder.

§ 300. An interesting attack of illness in three persons, owing to the consumption of the unboiled milk of a cow suffering from hæmorrhagic enteritis, is described by Gaffky (*Deutsch. Med. Wochenschrift*, 1892, No. 14).

§ 312. In the analysis of butter the oleorefractometer plays a part of increasing importance. See Jean (*Chimie Analytique des Matières Graisses.* Paris. 1892).

§ 332. On bacteria in flour see Hiltner (*Landwirthschaft, Versuchsstationen.*, 1891, xxxix. 471).

§ 338. On Pellagra, see C. Lembrono's monograph (*Trattate Profilattico e Clinics della Pellagra.* Torino. 1892).

§ 339. A careful examination of *Lolium temulentum*, by Fr. Hofmeister, has given decidedly different results from those of Antze (*Arch. f. Exp. Path.*, 1892, vol. xxx.).

§ 340. The baking powders containing alum and sodium carbonate, extensively used in England, disturb the pepsine digestion, according to Hehner, and occasion slight illness even in small doses (*Society of Public Analysts*, Oct. 5, 1892).

§ 340. Tonissari found in meal considerable quantities of caustic baryta as a widely diffused addition (!) Numerous cases of illness were the consequence of consuming such bread.

§ 341. In mouldy bread the relative proportion of nitrogen increases considerably from the partial disappearance of the carbohydrates.

§ 349. Oranges superficially stained with Biebrich scarlet are sold in Paris as blood oranges.

§ 356. Herr Wolffin, in my laboratory, could not confirm the statements of Tichomirow on the detection of extracted tea.

§ 356. For the analysis of tea see Domergue and Nicolas (*Journ. de Pharmacie et de Chemie*, 1892, p. 302; *Chem. Zeit. Rep.*, 1892, p. 126).

§ 356. On the alkaloids of tea compare Allen (*Pharm. Journal and Trans.*, 1892, p. 213; also *Chem. Zeit. Rep.*, 1892, p. 297).

§ 359. In Belgium falsifications of raw coffee-beans with artificial coffee-beans have been detected.

§ 359. Van Hamel Roos met with roasted coffee in trade, which had been extracted with ether (for the manufacture of coffee extract), and then roasted again. It contains only 1 instead of 13 to 14 per cent. of fat (*Revue Internationale des Falsificat.*, iv. 166).

§ 362. On the examination of tobacco smoke see Abeles and Paschkis (*Arch. f. Hygiene*, xiv. 20).

§ 363. On capsicum, its adulteration, see Von Bitto (*Chem. Zeit.*, 1892, p. 1836).

§ 374. Bertschinger found among twenty-eight Swiss beers none with a degree of fermentation up to 48 per cent.; among eleven celebrated German beers exported into Switzerland the degree of fermentation ranges from 47·5 to 61·7 per cent.

§ 384. Since 1891 Germany has adopted a rational wine law which meets the demands of hygiene and of national economy.

§ 387. Of late very good results have been obtained by fermenting grape juice with noble yeasts.

§ 390. In the determination of glycerine improvements have been effected in the first place by the critical work of Suhr (*Arch. f. Hygiene*, xiv. 305). He combines different new methods, and proceeds as follows :—He steams to expel the alcohol in part, distils off the glycerine from the residue at a reduced atmospheric pressure, precipitates the glycerine with benzol chloride (adding potassa-lye) as benzol ester, which is filtered off, dried and weighed, or determined volumetrically.

It is also recommended to titrate with permanganate after distilling off the glycerine as above (Fox, Benedict-Zsigmondi, Schaumann).

§ 391. On the acidity of wine and its determination, compare J. A. Müller (*Ann. Chim. Phys.*, 1591, 6th series, xxv. 118).

§ 393. According to C. Schmitt, wine prepared *secundum artem* contains the sulphurous acid, not as such, but as sulphaldehydic acid, which is said to have no action on the organism.

§ 397. Lintner considers the results of the experiments of Medicus and Immerheiser as determined by the use of yeast containing bacteria. Dextrine, according to Lintner, cannot be fermented by pure *Saccharomyces cerevisiæ* (*Zeit. f. Angewandte Chemie*, 1892, p. 328).

§ 401. The degypsifying wines with salts of barium is decidedly to be condemned ; also the use of stontium salts is prohibited in France as injurious to health.

§ 403. According to Schaffer and Von Freudenreich, sound natural wines free from water contain no bacteria. In artificial wines bacteria are found regularly.

§ 405. The chief difference between wine and cider and perry is in the absence of tartaric acid in the two latter. The tartaric acid may disappear also in grape wines which are diseased or strongly plastered.

§ 408. On absinthe see Sohet (*Revue Internat. des Falsifications*, iv. 110).

§ 417–419. Rubner (*Arch. f. Hygiene*, xv. 29) has enriched the examination of materials for clothing with new methods and results.

1. Determination of the thickness of clothing materials.

From eight to sixteen discs of the materials are laid upon each other, and the total thickness is measured under different pressures. There is manifested the great compressibility of knitted tissues and flannels as compared with linen and cotton.

2. Determination of total thickness of human clothing. A needle is thrust through the clothing until its point just touches the skin, and a disc of cork is made to slide upon the needle until it touches the outer surface of the clothing. We thus obtain the thickness of the clothing

sive of the interjacent layers of air. The latter are ascertained by subtracting the thickness of the several tissues from the thickness of the total clothing.

4. From a determination of the surface weight of different tissues and their thickness, we find the specific gravity of the clothing materials.

The specific gravity varies enormously with the proportion of air, for cotton from 0·147 to 0·768, for wool from 0·095 (yarn) to 0·358 (flannel).

5. The specific gravity of clothing materials free from air is for silk, cotton, and wool almost exactly = 1·3. Hence, and from the specific gravity of the clothing, we may calculate the volume of the pores. In 1000 parts by bulk of woollen flannel it is not less than 923.

This investigation contains new results concerning the behaviour of the tissues with water.

§ 431. Emmerich (*Arch. f. Hygiene*, xiv. 243) determines the moisture in mortar by drying large specimens in a vacuum exsiccator. The apparatus employed is unfortunately rather expensive.

§ 447. In a room strongly lighted with gas, A. V. Bibra found in a number of careful experiments 1 to 2 *mgrm.* N_2O_3 per litre. He discusses the toxicological literature of N_2O_3 at length, but without original experiments on animals (*Arch. f. Hygiene*, xv. 216).

§ 447. In an abstract Kirchner correctly points out that Weber's photometer gives us a measure for the magnitude of the illumination, whilst the spacial angle-metre measures its quality.

§ 451. According to Thomson the quantity of smoke in a chimney flue can be determined by the discoloration of a slip of white paper (kept cold) in a given time (*Journal of Gas Lighting*, 1892, 437).

§ 456. As a large work of reference on all questions on house building, we must recommend *Baukunde des Architecten*. 1891. Berlin. Töche).

§ 489. Cheese attacks nickel vessels remarkably strongly, perhaps in consequence of the formation of valerianic acid (Hellig, *Chem. Zeit. Rep.*, 1892, p. 212).

§ 490*a*. Aluminium. See Lunge and E. Schmid (*Chem. Zeit. Rep.*, 1892, p. 37), and Rupp (*Chem. Zeit. Rep.*, 1892, p. 21); Ohlmüller and Heise (*Arbeit aus dem k. Gesundheitsamt*, viii. 377).

§ 494. On the poisonous character of methylen blue, compare Galliard (*Toxicité du bleu de Méthylene, Revue Internat. des Fals.*, iv. 181), and Guttmann and Ehrlich (*Ueber die Wirkung des Methylenblaus bei Malaria, Berlin Klin. Wochenschrift*, 1891, No. 39).

§ 495. Bulewsky has concluded a very valuable study on the examination of and the decision on caoutchouc articles (*Arch. f. Hygiene*, xv. part ii.).

All caoutchouc articles with which children come in contact are harmless if (1) they float in water; (2) if they are elastic; (3) if they are of a soft consistence. Black dolls, coloured in the mass, contain lead oxide, and are poisonous (they sink in water). Red and reddish brown dolls, dyed in the mass, contain antimony sulphide (Sb_2S_5), and are harmless. All grey articles of caoutchouc at which children often suck (*e.g.*, grey teats) are relatively pernicious, as they contain zinc oxide. Caoutchouc articles are often superficially stained with poisonous colours.

§ 501. On the advantages of the use of hot solutions of chemical disinfectants, see Adolf Heider (*Arch. f. Hygiene*, xv. part iv.).

INSTRUCTIONS FOR THE USE OF THE TABLES (INTERPOLATION).

The following tables are of two kinds. The one group (I., II., VII. IX., X.) require no further explanation; their indications are at once intelligible, as they contain simple constants.

The tables III., IV., V., VI., &c., on the contrary, give laws according to which the magnitudes are mutually dependent, *e.g.*, the proportion of fat and the specific gravity. It is plain that the table can merely regard individual cases, and does not give direct answers to the questions with which we are engaged. In such cases the value required is found by simple calculation (interpolation), as will be shown in two examples.

1. How great is the highest possible atmospheric moisture, and the corresponding vapour tension at 24·7°?

	Max. Tension.	Highest possible Moisture.
According to Table VI. at 24° =	22·2 *mm.*	21·5 *grm.*
„ „ „ 25° =	23·6 *mm.*	22·9 *grm.*
Difference for 1° =	1·4 *mm.*	or 1.4 *grm.*

If the temperature in the interval between 24° and 25° rises by 0·1°, the tension rises by 0·14 *mm.* and the highest possible moisture by 0·14 *grm.* Hence for 24·7° the maximum tension is $22·2 + 7 \times 0·14 = 23·18$ *mm.*, and the maximum moisture $= 21·5 + 7 \times 0·14 = 22·48$ *grm.*

2. (*a.*) A sample of unskimmed milk had at 10° the specific gravity 1·0243, or marked 24·3, what will it mark at the conventional normal temperature 15°?

In Table XI. we look down the column headed 10, and find the number 24·3. If we proceed horizontally in this line to the column 15, we find there the number 25, and know that at 15° the milk would mark 25°.

(*b.*) If the milk at 10° Centigrade marked only 24·6°, we cannot find this number in column 10, and have to interpolate. The two nearest values in the column 10 are 24·3 and 25·3.

Milk weighing 24·3 would be (according to column 15) 25°.
„ „ 25·3 „ „ „ 26°.

For every tenth which the weight of the milk increases in the interval from 24·3 to 25·3, it weighs one-tenth heavier at 15°. Hence at 15° the sample would have the specific gravity: $24·6 + 7 \times 0·1 = 25·3$.

(*c.*) Double interpolation is required in the following example: Skimmed milk at 25·3° Cent. weighs 33·5°, what will it weigh at 15°?

According to Table XI. *a.*:

If at 25° it weighed 33, at 15° it would be 31.
„ 25° „ 34·1, „ 15° „ „ 32.

Therefore for 0·1 which the milk increases in weight at 25°, it is 0·09 heavier at 15°.

If at 26° it weighed 33·2, at 15° it would be 31.
„ 26° „ „ 34·3, „ 15° „ „ 32.

Therefore for each 0·1 which the milk weighs heavier at 26°, at 15° it weighs 0·09 heavier. Consequently if at 25° it weighed 33·5, at 15° the weight would be $31 + 5 \times 0{\cdot}09 = 31{\cdot}45$; if it weighs 33·5 at 26°, the weight at 15° will be $31 + 3 \times 0{\cdot}09 = 31{\cdot}27$.

From these two values the exact value may be deduced as follows:—

Milk which at 25° weighs 33·5, has at 15° the specific gravity 31·45.
„ „ 26° „ 33·5, „ 15° „ „ 31·27.

Or for a decrease of 1° = 0·22.

Hence for 25·3° $31{\cdot}45 - 3 \times 0{\cdot}002 = 31{\cdot}45 - 0{\cdot}066 = 31{\cdot}384$.

This last calculation to three decimal places has no practical value, as the accuracy of the entire table does not extend beyond the first decimal place.

TABLE I.—*Reduction of some Weights and Measures to the Metric System.*

Country.	Small Measures.	Metre.	Large Measures.	Kilometres.	1 Square Foot = Sq. Metre	Superficial.	Hectares.	Cubic Measures.	Litre.	Weight.	
Bavaria . .	Foot 10 or 12 inches at 10 or 12 lines	0·29186	Mile, geogr. 15 = 1°	7·42044	0·0852	Juchart (40,000 *q'*)	0·34073	Maass 208 = 1 scheffel	1·069	Pound	560 *g.*
Britain .	Foot 12 inches at 10 lines	0·30479	Mile (5280') 1760 yards	1·60931	0·092899	Acre (43,560 *q'*)	0·40467	Gallon 8 = 1 bushel	4·543	Pound (16 ounces)	453·6 *g.* Avoir-dupois
United States .	3 feet = 1 yard	...	...	...	...	...	...	...	...	Pound (12 ounces)	373·2 *g.* Troy
Austria . .	Foot 12 in. at 12 lines	0·31611	Mile (24,000')	7·58666	0·099928	Joch (57,600 *q'*)	0·57557	Maass 43·46 = 1 metze	1·415	Pound (32 loth)	560 *g.*
Prussia . .	Foot 12 in. at 12 lines	0·31385	Mile (24,000')	7·53248	0·098504	Morgen (25,920 *q'*)	0·25532	Quart 48 = 1 scheffel	1·145	Pound (32 loth)	467·7 *g.*
Paris . . .	Foot 12 in. at 12 lines	0·32484	...	...	0·105521	...	...	...	...	...	...
Russia . .	Foot 2⅓' = 1 arschin 12 in. at 10 lines	0·30479	Werst (3500')	1·06678	0·092907	Dessjätine (117,600 *q'*)	1·09250	Stoof 64 = 3 tschetwerik ; 170⅔ = 1 tschetwert	1·229	Pound (40 = 1 pud)	409·5 *g.*
Switzerland	Foot 10 in. at 10 lines	0·30000	Hour (16,000')	4·80000	0·090000	Juchart (40,000 *q'*)	0·36000	Maass 100 = 1 malter	1·500	Pound (32 loth)	500 *g.*
Würtemberg	Foot	0·28649	Mile (12 = 1°)	9·27570	0·59667	Morgen (38,400 *q'*)	0·31517	Helleichmaass 96·47 = 1 scheffel	1·837	Pound (32 loth)	467·7 *g.*

Note.—The Rhenish and the Danish foot equals the Prussian foot; the Baden foot equals the Swiss. The medicinal and apothecaries weight formerly used in Germany was 1 pound (℔) = 350·783 *grm.*) of 12 ounces (1 ounce (℥) = 30 *grm.*) at 8 drams (1 dram (ʒ) = 3·75 *grm.*) at 3 scruples (1 scruple (℈) = 1·25 *grm.*) of 20 grains (1 grain = 0·06 *grm.*).

[1] The American liquid measure is the old English wine measure.—*Editor.*

TABLE II.

Coefficient of Expansion (α) of some Important Solids.

The linear expansion takes place according to the formula $= V_t = V_o (1 + \alpha t)$. Cubic expansion according to the formula $= V_o (1 + 3\alpha t)$.

Glass . . .	0·0000086	Brass . . .	0·0000185
Iron . . .	0·0000110	Silver . .	0·0000191
Copper . .	0·0000172	Zinc . . .	0·0000294

Cubic Coefficient of Expansion (α) of some Liquids and Gases.

Cubic expansion takes place according to the formula $V_t = V_o (1 + \alpha\ t)$.

Ether	0·0021
Alcohol (absolute)	0·0012
Water	0·0001 (at 25°)
Mercury	0·000181

The coefficients for alcohol, ether, and water hold good only for temperatures near the temperature of a dwelling-room (20°); for water α at $50° = 1·00024$, and at $100° = 1·00043$.

For all gases and gaseous mixtures $\alpha = 0·00366$, supposing that they are not observed too near their point of condensation.

TABLE III.

Boiling Point of Water.

Barometer.	Temperature.	Barometer.	Temperature.	Barometer.	Temperature.
580	92·6	650	95·7	720	98·5
585	92·8	655	95·9	725	98·7
590	93·1	660	96·1	730	98·9
595	93·3	665	96·3	735	99·1
600	93·5	670	96·5	740	99·3
605	93·7	675	96·7	745	99·4
610	94·0	680	96·9	750	99·6
615	94·2	685	97·1	755	99·8
620	94·4	690	97·3	760	100·0
625	94·6	695	97·5	765	100·2
630	94·8	700	97·7	770	100·4
635	95·1	705	97·9	775	100·5
640	95·3	710	98·1		
645	95·5	715	98·3		

TABLE IV.

Reduction of Heights of Barometer expressed in Millimetres to 0°.

Temperature read off.	Barometer as read off.									
	700 mm.	710 mm.	720 mm.	730 mm.	740 mm.	750 mm.	760 mm.	770 mm.	780 mm.	790 mm.
—10°	+1·1	+1·2	+1·2	+1·2	+1·2	+1·2	+1·2	+1·3	+1·3	+1·3
— 9	+1·0	+1·0	+1·1	+1·1	+1·1	+1·1	+1·1	+1·1	+1·1	+1·2
— 8	+0·9	+0·9	+0·9	+1·0	+1·0	+1·0	+1·0	+1·0	+1·0	+1·0
— 7	+0·8	+0·8	+0·8	+0·8	+0·8	+0·9	+0·9	+0·9	+0·9	+0·9
— 6	+0·7	+0·7	+0·7	+0·7	+0·7	+0·7	+0·7	+0·8	+0·8	+0·8
— 5	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6
— 4	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5
— 3	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4
— 2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·3	+0·3
— 1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1
0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
+ 1	—0·1	—0·1	—0·1	—0·1	—0·1	—0·1	—0·1	—0·1	—0·1	—0·1
2	—0·2	—0·2	—0·2	—0·2	—0·2	—0·2	—0·2	—0·3	—0·3	—0·3
3	—0·3	—0·3	—0·4	—0·4	—0·4	—0·4	—0·4	—0·4	—0·4	—0·4
4	—0·5	—0·5	—0·5	—0·5	—0·5	—0·5	—0·5	—0·5	—0·5	—0·5
5	—0·6	—0·6	—0·6	—0·6	—0·6	—0·6	—0·6	—0·6	—0·6	—0·6
6	—0·7	—0·7	—0·7	—0·7	—0·7	—0·7	—0·7	—0·8	—0·8	—0·8
7	—0·8	—0·8	—0·8	—0·8	—0·8	—0·9	—0·9	—0·9	—0·9	—0·9
8	—0·9	—0·9	—0·9	—1·0	—1·0	—1·0	—1·0	—1·0	—1·0	—1·0
9	—1·0	—1·0	—1·1	—1·1	—1·1	—1·1	—1·1	—1·1	—1·1	—1·2
10	—1·1	—1·2	—1·2	—1·2	—1·2	—1·2	—1·2	—1·3	—1·3	—1·3
11	—1·3	—1·3	—1·3	—1·3	—1·3	—1·3	—1·4	—1·4	—1·4	—1·4
12	—1·4	—1·4	—1·4	—1·4	—1·5	—1·5	—1·5	—1·5	—1·5	—1·5
13	—1·5	—1·5	—1·5	—1·5	—1·6	—1·6	—1·6	—1·6	—1·7	—1·7
14	—1·6	—1·6	—1·6	—1·7	—1·7	—1·7	—1·7	—1·8	—1·8	—1·8
15	—1·7	—1·7	—1·8	—1·8	—1·8	—1·8	—1·9	—1·9	—1·9	—1·9
16	—1·8	—1·9	—1·9	—1·9	—1·9	—2·0	—2·0	—2·0	—2·0	—2·1
17	—1·9	—2·0	—2·0	—2·0	—2·1	—2·1	—2·1	—2·1	—2·2	—2·2
18	—2·1	—2·1	—2·1	—2·1	—2·2	—2·2	—2·2	—2·3	—2·3	—2·3
19	—2·2	—2·2	—2·2	—2·3	—2·3	—2·3	—2·4	—2·4	—2·4	—2·5
20	—2·3	—2·3	—2·4	—2·4	—2·4	—2·5	—2·5	—2·5	—2·5	—2·6
21	—2·4	—2·4	—2·5	—2·5	—2·5	—2·6	—2·6	—2·6	—2·7	—2·7
22	—2·5	—2·6	—2·6	—2·6	—2·7	—2·7	—2·7	—2·8	—2·8	—2·8
23	—2·6	—2·7	—2·7	—2·7	—2·8	—2·8	—2·9	—2·9	—2·9	—3·0
24	—2·7	—2·8	—2·8	—2·9	—2·9	—2·9	—3·0	—3·0	—3·1	—3·1
25	—2·9	—2·9	—2·9	—3·0	—3·0	—3·1	—3·1	—3·1	—3·2	—3·2
26	—3·0	—3·0	—3·1	—3·1	—3·1	—3·2	—3·2	—3·3	—3·3	—3·4
27	—3·1	—3·1	—3·2	—3·2	—3·3	—3·3	—3·4	—3·4	—3·4	—3·5
28	—3·2	—3·3	—3·3	—3·3	—3·4	—3·4	—3·5	—3·5	—3·6	—3·6
29	—3·3	—3·4	—3·4	—3·5	—3·5	—3·6	—3·6	—3·7	—3·7	—3·7
30	—3·4	—3·5	—3·5	—3·6	—3·6	—3·7	—3·7	—3·8	—3·8	—3·9
31	—3·5	—3·6	—3·7	—3·7	—3·8	—3·8	—3·9	—3·9	—4·0	—4·0
32	—3·7	—3·7	—3·8	—3·8	—3·9	—3·9	—4·0	—4·0	—4·1	—4·1
33	—3·8	—3·8	—3·9	—3·9	—4·0	—4·0	—4·1	—4·2	—4·2	—4·3
34	—3·9	—3·9	—4·0	—4·1	—4·1	—4·2	—4·2	—4·3	—4·3	—4·4
35	—4·0	—4·1	—4·1	—4·2	—4·2	—4·3	—4·4	—4·4	—4·5	—4·5

Example:—At 25° the reading of the barometer is 720 *mm.*, at 0° it is 720 − 2·9 = 717·1 *mm.*

TABLE V.

At the following temperatures and barometric readings, columns of air of x metres in height counterpoise 1 *mm. mercury.* (*See* § 108.)

	30°.	20°.	10°.	0°.	−10°.		30°.	20°.	10°.	0°.	−10°.
780	11·48	11·06	10·66	10·24	9·82	720	12·43	11·99	11·55	11·10	10·65
770	11·63	11·21	10·80	10·38	9·96	710	12·61	12·16	11·71	11·26	10·81
760	11·78	11·36	10·94	10·52	10·11	700	12·79	12·33	11·87	11·42	10·97
750	11·94	11·51	11·08	10·66	10·24	690	12·98	12·51	12·05	11·59	11·13
740	12·10	11·67	11·23	10·80	10·37	680	13·16	12·69	12·22	11·75	11·28
730	12·25	11·82	11·38	10·94	10·50	670	13·37	12·89	12·41	11·93	11·45

TABLE VI.

Maximum possible water in 1 *cbm. of air in grammes. Maximum possible tension of atmospheric moisture in millimetres of mercury at different temperatures.*

Temperature.	Tension.	Grammes Water.	Temperature.	Tension.	Grammes Water.	Temperature.	Tension.	Grammes Water.
−10°	2·0	2·1	8°	8·0	8·1	21°	18·5	18·2
− 8	2·4	2·7	9	8·5	8·8	22	19·7	19·3
− 6	2·8	3·2	10	9·1	9·4	23	20·9	20·4
− 4	3·3	3·8	11	9·8	10·0	24	22·2	21·5
− 2	3·9	4·4	12	10·4	10·6	25	23·6	22·9
0	4·6	4·9	13	11·1	11·3	26	25·0	24·2
1	4·9	5·2	14	11·9	12·0	27	26·5	25·6
2	5·3	5·6	15	12·7	12·8	28	28·1	27·0
3	5·7	6·0	16	13·5	13·6	29	29·8	28·6
4	6·1	6·4	17	14·4	14·5	30	31·6	30·1
5	6·5	6·8	18	15·2	15·1	50		83·4
6	7·0	7·3	19	16·3	16·2	70		199·3
7	7·5	7·7	20	17·4	17·2			

TABLE VII.

Weight of some Gases and Vapours at 0° *and* 760 *mm.*

	1 *cc.* weighs *mgrm.*	1 *mgrm.* has a Volume of *cc.*		1 *cc.* weighs *mgrm.*	1 *mgrm.* has a Volume of *cc.*
Oxygen . . .	1·430	0·699	Hydrogen chloride .	1·635	0·612
Hydrogen . .	0·089	11·496	Hydrogen sulphide .	1·522	0·657
Nitrogen . .	1·256	0·796	Ammonia	0·761	1·314
Chlorine . . .	3·18	0·314	Sulphurous acid . .	2·87	0·349
Bromine . . .	7·16	0·140	Carbon dioxide . .	1·977	0·506
Iodine . . .	11·3	0·088	Air	1·293	0·774
Mercury . . .	8·9	0·112			

TABLE VIII.

Determination of Hardness by Titration with Soap, according to Clark.

If Cubic Centimetre of Soap-Liquor consumed		The Hardness is
3·4	In this interval a + consumption of soap-liquor of 0·4 *cc.* of soap represents an increased hardness of 0·1 degree or 1 *cc.* soap = 0·25°.	0·5
5·4		1·0
7·4		1·5
9·4		2·0
11·3	In this interval a + consumption of 0·38 *cc.* soap represents an increased hardness of 0·1 degree or 1 *cc.* soap = 0·26.	2·5
13·2		3·0
15·1		3·5
17·0		4·0
18·9		4·5
20·8		5·0
22·6	In this interval a + consumption of 0·36 *cc.* of soap represents an increased hardness of 0·1 degree or 1 *cc.* soap = 0·277.	5·5
24·4		6·0
26·2		6·5
28·0		7·0
29·8		7·5
31·6		8·0
33·3	In this interval a + consumption of 0·34 *cc.* of soap represents an increased hardness of 0·1 degree or 1 *cc.* soap = 0·294.	8·5
35·0		9·0
36·7		9·5
38·4		10·0
40·1		10·5
41·8		11·0
43·4	In this interval a + consumption of 0·32 *cc.* soap represents an increased hardness of 0·1 degree or 1 *cc.* soap = 0·31.	11·5
45·0		12·0

TABLE IX.

Mean Composition of Animal Foods, &c., according to König.

A. Animal Foods, &c.

Meat and its Preparations, Fish, Eggs.	In Natural State.					Dried.			
	Water.	Nitrogenous Matter.	Fat.	Non-Nitrogenous Extract.	Ash.	Nitrogenous Matter.	Fat.	Non-Nitrogenous Extract.	Ash.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Beef, very fat	53·05	16·75	29·28	...	0·92	35·68	62·37	...	1·95
,, medium	73·03	20·96	5·41	0·46	1·14	77·59	20·03	0·16	4·22
,, lean	76·37	20·71	1·74	...	1·18	87·65	7·16	...	5·19
Veal, fat	72·31	18·88	7·41	0·07	1·33	68·17	26·76	0·27	4·80
,, lean	78·84	19·86	0·82	...	0·50	93·86	3·88	...	2·26
Mutton, very fat	53·31	16·62	28·61	0·54	0·93	35·60	61·28	1·13	1·99
,, medium	75·99	17·11	5·77	...	1·33	71·26	23·20	...	5·54
Pork, fat	47·40	14·54	37·34	...	0·72	27·64	70·98	...	1·38
,, lean	72·57	20·25	6·81	...	1·10	73·83	24·83	...	1·34
Horse-flesh	74·27	21·71	2·55	0·46	1·01	84·39	9·91	1·77	3·93
Blood[1]	80·82	18·12	0·18	0·03	0·85	94·48	0·94	0·15	4·43
Herring	74·64	14·55	9·03	...	1·78	57·16	35·84	...	7·00
Pike	79·63	18·42	0·53	0·46	0·96	90·42	2·60	2·27	4·71
Shell-fish	81·50	16·93	0·26	...	1·31	91·51	1·41	...	7·08
Carp	76·97	21·86	1·09	...	1·33	94·92	4·73	...	5·77
Dry shell-fish, not salt	16·16	81·54	0·74	...	1·56	97·28	0·88	...	1·84
,, ,, salt	13·20	73·73	3·37	...	9·92	84·94	3·88	...	11·18
Salt cod	50·54	27·07	0·36	...	22·10	54·74	0·73	...	44·53
Hare	74·16	23·34	1·13	0·19	1·18	90·33	4·37	0·73	4·57
Fowl, lean	76·22	19·72	1·42	1·27	1·37	82·92	5·97	5·35	5·76
,, fat	70·06	18·49	9·34	1·20	0·91	61·76	31·20	3·00	3·04
Meat powder, dried meat	10·99	69·50	5·84	0·42	13·25	78·05	6·56	0·51	14·88
Beef, smoked	47·68	27·10	15·35	...	10·59	51·79	29·33	...	20·24
Ham, smoked, Westphalian	28·11	24·74	36·45	0·16	10·54	34·41	50·70	0·23	14·66
Canned meat, American	55·80	29·04	11·54	...	3·62	65·69	26·12	...	8·19
Ham sausage	46·87	12·87	24·43	12·52	3·31	24·22	45·98	23·57	6·23
Meat sausage	20·76	27·31	39·88	5·10	6·95	34·48	50·33	6·42	8·77
Cervelat sausages	37·37	17·64	39·76	...	5·44	28·06	63·46	...	8·48
Small Frankfurt sausages	42·79	11·69	39·61	2·25	3·66	20·04	69·22	2·34	8·40

[1] We must, of course, protest against blood ranking as an article of food. —*Editor.*

TABLE IX. (*continued*).

Meat and its Preparations, Fish, Eggs.	In Natural State.					Dried.			
	Water.	Nitrogenous Matter.	Fat.	Non-Nitrogenous Extract.	Ash.	Nitrogenous Matter.	Fat.	Non-Nitrogenous Matter.	Ash.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Blood sausage	49·03	11·81	11·48	25·00	1·69	23·58	22·93	50·22	3·27
,, ordinary	63·61	9·93	8·87	15·83	1·76	27·36	25·50	44·06	3·08
Liver sausage, I.	48·70	15·93	26·35	6·38	2·66	31·05	51·32	12·45	5·18
,, ,, II.	47·80	12·89	25·10	12·22	2·21	24·70	48·09	22·08	4·23
,, ,, III.	51·66	9·98	14·60	22·78	1·98	20·67	30·21	46·02	3·10
Sulzen sausage	41·50	23·10	22·8	...	12·60	39·48	38·97	...	21·55
Knack sausage	58·60	22·8	1·4	...	7·2	55·08	27·53	...	17·39
Hens' eggs	73·67	12·55	12·11	0·55	1·12	47.69	46·02	1·03	4·20
,, white	85·5	12·87	0·25	0·77	0·61	87·87	1·71	6·25	4·17
,, yolk	51·03	16·12	31·39	0·48	1·01	32·02	64·10	0·92	2·06
Milk and Dairy Produce.				Non-Nitrogenous Extract and Sugar.				Non-Nitrogenous Matter and Sugar.	
Woman's milk	87·41	2·29	3·78	6·21	0·31	18·19	30·02	49·33	2·40
Cows' milk	87·17	3·55	3·69	4·88	0·71	27·07	28·74	38·86	5·53
Goats' milk	85·71	4·29	4·78	4·46	0·76	30·02	33·45	31·21	5·32
Sheep's milk	80·82	6·52	6·86	4·91	0·89	34·00	35·77	25·59	4·64
Condensed cows' milk. without sugar, slightly condensed	72·87	8·2	6·62	10·63	1·68	30·23	24·40	38·18	6·19
Condensed cows' milk. without sugar, strongly condensed	58·99	11·92	12·42	14·49	2·18	29·06	30·28	35·35	5·31
Condensed cows' milk. with sugar	25·61	11·79	10·35	50·0	2·19	15·85	13·91	67·30	2·94
Cream	68·82	3·76	22·6	4·23	0·53	12·06	72·67	13·57	1·70
Butter	13·59	0·74	84·39	0·62	0·66	0·86	97·64	0·74	0·76
Cream cheese	36·33	18·84	40·71	1·02	3·10	20·60	63·96	1·57	4·87
Rich cheese	38·00	25·35	30·25	1·43	4·97	40·89	48·79	2·30	8·02
Semi-rich cheese	39·79	29·67	23·92	1·79	4·73	49·23	39·68	3·24	7·85
Lean cheese	46·00	34·06	11·65	3·42	4·87	63·08	21·58	6·32	9·02
Sour milk cheese	52·36	36·64	6·03	0·9	4·07	76·91	12·66	2·09	8·54
Skim milk. on standing	90·68	3·03	0·70	4·84	0·75	32·51	7·51	51·39	8·05
Skim milk. centrifugal	90·60	3·06	0·31	5·29	0·74	32·52	3·29	56·33	7·86
Butter milk	90·12	4·03	1·09	4·04	0·72	40·79	1·10	50·82	7·29

TABLE IX. (*continued*).

B. Vegetable Foods.

	In Natural State.								Dried.						
	Water.	Nitrogenous Matter.	Fat.	Sugar.	Dextrine and gum.	Starch.	Cellulose.	Ash.	Nitrogenous Matter.	Fat.	Sugar.	Dextrine and gum.	Starch.	Cellulose.	Ash.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Wheat	13·37	12·04	1·85	3·25	2·54	62·86	2·31	1·78	13·89	2·13	3·87	2·93	72·46	2·67	2·05
Spelt	13·37	11·84	1·85	0·98	1·72	65·52	2·65	2·07	13·66	2·13	1·13	1·98	75 65	3·06	2·39
Rye	13·37	10·81	1·77	1·87	4·57	63·77	1·78	2·06	12·47	2·04	2·16	5·27	73 63	2·05	2·38
Barley	14·05	9·66	1·93	1·23	3·75	62·01	4·95	2·42	11·23	2·24	1·43	4·36	72·17	5·76	2·81
Oats	12·11	10·66	4·90	1·72	1·89	54·76	10·58	3·29	12·13	5·68	1·96	2·15	62·30	12·04	3·74
Maize	13·35	9·45	4·29	2·29	2·06	64·98	2·29	1·29	10·90	4·95	2·64	2·38	75·00	2·64	1·49
Rice, shelled for cooking	12·58	6·73	0·88	0·15	0·77	77·56	0·51	0·82	7·70	1·01	0 17	0·88	88·72	0·58	0·94
Buckwheat, peeled	12·68	10·18	1·90		71·73		1·65	1·86	11·66	2·18		82·14		1·89	2·13
Peas	13·92	23·15	1·89		52·68		5·68	2·68	26·88	2·19		61·23		6·59	3·11
Beans (*Faba vulgaris*)	13·49	25·31	1·68		48·33		8·06	3·13	29·26	1·94		55·86		9·32	3·62
Kidney beans (*Phaseolus vulgaris*)	11·24	23·66	1·96		55·60		3·88	3·66	26·66	2·21		62·64		4·37	4·12
Lentils (*Ervum lens*)	12·33	25 94	1·93		52 84		3·92	3·04	29·60	2·20		60·26		4·47	3·47
Soja beans, yellow	9·89	33·41	17·68		29·31		4·67	5·10	37·09	19·62		32·45		5·18	5·66
Wheat flour, fine	13·37	10·21	0·94	2·35	3·06	69·30	0·29	0·48	11·79	1·08	2·71	3·53	80·01	0·33	0·55
„ „ coarse	12·81	12 06	1·36	1·86	4·09	65·88	0·98	0·96	13·83	1·56	2·13	4·69	75·57	1·12	1·10

Wheat flour, according to Graham	13·00	11·70	1·70		69·90		1·90	1·80	13·44	1·95		80·36		2·18	2·07
Whole meal	13·05	9·43	0·94		75·92		0·21	0·40	10·84	1·08		87·38		0·24	0·46
Wheat groats	12·82	7·25	1·15		76·19		1·36	1·23	8·32	1·32		87·39		1·56	1·41
Rye meal	13·71	11·57	2·08	3·89	7·16	58·66	1·59	1·44	13·41	2·41	4·51	8·30	68·06	1·84	1·67
Barley meal	14·83	11·38	1·53	3·11	6·52	61·60	0·45	0·59	13·36	1·80	3·65	7·65	73·82	0·53	0·69
Oat meal	9·65	13·44	5·92	2·26	3·08	61·67	1·86	2·12	14·88	6·55	2·51	2·41	69·24	2·06	2·35
Maize meal	14·21	9·65	3·80	3·56	3·36	62·63	1·46	1·33	11·21	4·42	4·14	3·90	72·81	1 97	1·55
Ground rice	12·82	6·91	0·67		78·84		0·18	0·58	7·93	0·77		90·42		0·21	0·67
Millet meal	10·30	9·81	8·80	1·30	9·30	59·03	1·46	1·46	10·94	9·81	1·45	10·37	65·80		1·63
Bean meal	10·29	23·19	2·13		59·37		1·67	3·35	25·88	2·38		66·10		1·86	3·74
Pea meal	11·41	25·20	2·10		57·17		1·32	2·89	28·45	2·27		64·53		1·49	3·26
Lentil meal	10·73	25·46	1·83		57·35		2·01	2·62	28·52	2·05		64·25		2·25	2·93
Potato meal	17·18	1·03	...		80·83		...	0·96	1·24	...		97·60		...	1·16
Starch	16·04	1·18	0·06		82·13		0·13	0·36	1·41	0·07		97·94		0·15	0·43
Wheat bread, fine	35·59	7·06	0·46	4·02	52·56		0·32	1·09	10·95	0·71	6·24	79·91		0·50	1·69
" " coarse	40·45	6·15	0·44	2·08	49·04		0·62	1·22	9·71	0·69	2·28	84·41		0 98	1·93
Wheat rusks	13·28	8·55	0·98	1·82	73·28		0·59	1·50	9·86	1·13	2·10	84·50		0·68	1·73
Rye bread	42·27	6·11	0·43	2·31	46·95		0·49	1·46	10·58	0·74	4·00	81·30		0·85	2·53
Pumpernickel	43·42	7·59	1·51	3·25	41·87		0·94	1·24	13·41	2·67	5·74	74·01		1·66	2·51
Ammunition bread (Prussian)	36·71	7·47	0·45	3·05	46·36		1·51	1·46	11·80	0·71	4·82	78·00		2·36	2·31
Fine wheat rusks	1·18	13·31	3·18	7·12	73·96		0·25	1·00	13·47	3·22	7·21	74·84		0·25	1·01
Potatoes	74·98	2·08	0·15	0·28	20·73		0·69	1·09	8·31	0·60	1·12	82·85		2·76	4·36

TABLE IX. (*continued*).

	In Natural State.							Dried.					
	Water.	Nitrogenous Matter.	Fat.	Sugar.	Non-Nitrogenous Extract.	Cellulose.	Ash.	Nitrogenous Matter.	Fat.	Sugar.	Non-Nitrogenous Extract.	Cellulose.	Ash.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Turnips	90·78	1·18	0·22	5·89		1·13	0·80	12·80	2·39	74·90		1·23	8·68
Carrots—													
Large sort	86·79	1·23	0·30	6·71	2·46	1·49	1·02	9·31	2·27	50·79	18·63	11·28	7·72
Small sort	88·84	1·07	0·21	1·58	6·59	0·98	0·73	9·59	1·88	14·16	59·05	8·78	6·54
Radish	86·92	1·92	0·11	1·53	6·90	1·55	1·07	14·66	0·84	11·70	51·77	12·85	8·18
,,	93·34	1·23	0·15	...	15·89	2·78	1·63	18·49	2·25	...	22·50	32·29	24·47
Kohl-rabi—													
Tubers	85·89	2·87	0·21	0·38	7·80	1·68	1·17	20·34	1·49	2·69	55·28	11·11	8·29
Leaves	86·04	2·03	0·45	0·51	6·77	1·55	1·65	14·54	3·22	3·65	55·87	11·10	11·82
Cucumber	95·20	1·18	0·09	0·96	1·35	0·78	0·44	24·58	1·88	20·00	27·12	16·25	9·17
Asparagus	93·75	1·79	0·25	0·37	2·26	1·04	0·54	28·64	4·00	5·92	40·16	12·64	8·64
Garden peas (green)	78·44	6·35	0·53	12·00		1·87	0·81	29·43	2·46	55·70		8·66	3·75
Cut beans	88·75	2·72	0·14	1·16	5·44	1·18	0·61	24·18	1·24	10·31	48·36	10·49	5·42
Cauliflower	90·89	2·48	0·34	1·21	3·34	0·91	0·83	27·12	3·73	13·28	36·77	9·99	9·11
Winter cabbage	80·03	3·99	0·90	1·21	10·42	1·88	1·57	19·98	4·51	6·06	52·17	9·42	7·86
Rose ,,	85·63	4·83	0·46	6·22		1·57	1·29	33·61	3·20	43·28		10·93	8·98
Red ,,	90·06	1·83	0·19	1·74	4·12	1·29	0·77	18·41	1·91	17·50	41·95	12·48	7·75

TABLE IX. (*continued*).—*Mushrooms and Fungi.*

	In Natural State.								Dried.						
	Water.	Nitrogenous Matter.	Fat.	Mannite.	Glucose.	Other Non-Nitrogenous Matter.	Cellulose.	Ash.	Nitrogenous Matter.	Fat.	Mannite.	Glucose.	Other Non-Nitrogenous Matter.	Cellulose.	Ash.
Fresh.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Mushroom	91·28	3·74	0·15	0·42	0·75	2·34	0·84	0·48	42·89	1·72	4·83	8·60	26·83	9·63	5·50
							1·04								
Other Agarics	88·77	3·04	0·35		5·90			0·9	27·11	3·12		52·46		9·28	8·03
Morel	90·00	3·00	0·19	0·65	·09	4·47	0·67	0·93	30·00	1·90	6·50	0·90	44·70	6·70	9·30
Truffle	72·8	8·06	0·62	8·01	...	...	7·57	2·31	29·13	2·28	...	31·97	...	27·83	8·49
Cantharellus cibarius	91·91	2·94	0·32		0·74	2·13	1·21	0·75	36·34	3·96		9·15	26·32	14·96	9·27
Hydnum repandum	92·68	1·79	0·34		1·68	1·84	1·03	0·69	24·45	4·64		2·30	45·11	14·07	9·43
Air-Dried.															
Mushroom	14·04	37·45	1·45	4·17	7·49	22·43	8·25	4·72	43·55	1·69	4·85	8·71	26·11	9·60	5·49
Morel	16·36	25·22	1·65	5·46	0·79	37·05	5·63	7·84	30·19	1·97	6·52	0·94	44·25	6·73	9·40
Boletus edulis	12·81	36·12	1·72	4·48	...	32·78	5·71	6·38	41·43	6·72	5·14	...	32·44	6·55	7·32
Cantharellus cibarius	16·48	30·32	3·26	8·27		21·49	12·48	7·70	36·29	3·90	9·90		25·75	14·94	9·22

TABLE IX. (*continued*).—*Fruits.*

	In Natural State.								Dried.						
	Water.	Nitrogenous Matter.	Fat.	Free Acid.	Sugar.	Other Non-nitrogenous Matter.	Cellulose.	Ash.	Nitrogenous Matter.	Fat.	Free Acid.	Sugar.	Non-Nitrogenous Matter.	Cellulose.	Ash.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
a. Fresh—															
Apples . . .	84·79	0·36	...	0·82	7·22	4·81	1·51	0·49	2·37	...	5·39	47·47	31·62	9·93	3·22
Damsons . . .	81·88	0·78	...	0·85	6·15	4·92	5·41	0·71	4·14	...	4·52	32·68	26·14	28·75	3·77
Cherries . . .	79·82	0·67	0·91	0·91	10·24	1·76	6·07	0·73	3·32	...	4·51	50·74	7·83	30·08	3·52
Strawberries . .	87·66	0·54	0·45	0·93	6·28	1·01	2·32	0·81	4·38	3·65	7·84	50·89	2·88	23·80	6·56
Bilberries . .	78·36	0·78	...	1·66	5·02	0·87	12·29	1·02	3·60	...	7·67	23·20	4·03	56·79	4·71
b. Dried—															
Apples . . .	27·95	1·28	0·82	3·60	42·83	16·96	4·99	1·57	1·78	1·14	5·00	59·45	23·52	6·93	2·18
Cherries . . .	49·88	2·07	3·30	...	31·22	14·29	0·61	1·63	4·13	0·60	...	62·28	26·56	3·18	3·25
Damsons . . .	29·30	2·25	0·48	2·75	44·41	17·91	1·52	1·37	3·89	6·69	3·89	62·88	18·71	2·15	1·78
c. Fruit juices—															
Raspberry juice (officinal) . .	39·60	...	...	...	60·45	...	...	...	...	...	...	...	...	...	...

TABLE X.—*Composition of Articles of Enjoyment.*

A. Spices.

	In Natural State.								Dried.						
	Water.	Nitrogenous Matter.	Volatile Oil.	Fixed Oil.	Starch.	Other Non-Nitrogenous Extract.	Cellulose.	Ash.	Nitrogenous Matter.	Volatile Oil.	Fixed Oil.	Starch.	Other Non-Nitrogenous Matter.	Cellulose.	Ash.
	Per Ct.	Per Ct.	Per Ct	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Pepper, black	13·65	11·98	1·36	6·85	32·60	7·39	12·45	4·02	13·68	1·56	7·64	37·49	20·69	14·32	4·62
„ white	13·75	11·12	0·94	7·11	40·31	3·35	6·08	1·61	12·89	1·09	8·24	46·72	19·52	9·67	1·87
Cayenne pepper	13·21	13·40	0·87	18·26	13·76		17·17	5·33	15·44	1·00	21·04	36·60		19·78	6·14
Cinnamon (Ceylonese)	8·94	3·66	1·65	2·00	48·62		31·39	3·74	4·02	1·81	2·20	53·79		34·47	4·11
Cinnamon (Chinese)	10·40	3·04	2·21	2·27	60·70		18·59	2·79	3·39	2·47	2·53	67·75		20·75	3·11
					Tannin.							Tannin.			
Cloves (best)	8·04	5·92	15·80	9·10	16·01	29·19	8·45	7·42	6·44	17·19	9·90	17·42	13·79	9·19	8·07
„ (inferior)	8·56	5·34	8·92	5·90	23·72	28·13	11·61	7·67	5·84	9·76	6·45	25·96	30·50	12·70	8·39
Pimento	8·18	4·75	3·00	6·34	9·38	46·84	17·44	4·07	5·17	3·27	6·9	10·21	51·13	18·99	4·43
					Sugar.							Sugar.			
Nutmegs	7·38	5·49	3·05	34·27	1·58	35·61	9·92	2·70	5·97	3·29	37·0	1·71	39·4	10·71	2·92
„ (Mace)	9·65	5·30	6·66	24·63	2·15	42·66	6·31	2·64	5·86	7·37	27·27	2·38	46·21	9·99	2·92
Vanilla	28·39	3·71	0·62	5·71	8·09	31·70	17·43	4·63	4·37	0·87	7·97	10·49	47·51	24·33	4·46
Saffron	16·07	11·74	0·60	3·22	15·33	44·57	4·37	3·37	13·99	0·72	3·84	18·28	52·96	5·20	5·21
Aniseed	11·42	16·31	1·92	8·36	3·89	23·96	25·23	8·91	18·41	2·17	9·44	4·39	31·05	28·48	10·06
Carraway	13·23	19·43	1·74	17·30	2·14	18·20	22·41	5·55	22·38	2·00	13·92	2·47	27·03	25·87	6·39

TABLE X. (*continued*).

B. Alkaloidal Articles of Enjoyment.

	In Natural State.								Dried.						
	Water.	Nitrogenous Matter, N = 6·25 per Cent.	Alkaloid.	Fat.	Sugar.	Other Non-Nitrogenous Matter	Cellulose.	Ash.	Nitrogenous Matter.	Alkaloid.	Fat.	Other Non-Nitrogenous Matter.	Cellulose.	Ash.	Sugar.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Coffee, raw	11·23	12·07	1·21	12·27	8·55	33·79	18·17	3·92	13·60	1·36	13·83	64·09	2·05	4·42	0·65
„ burnt	1·15	13·98	1·24	14·48	0·66	45·09	19·89	4·75	14·15	1·25	14·65	43·04	21·13	4·81	0·67
					Gallic Acid.										Gallic Acid.
Tea	9·51	24·50	3·58	7·07	15·66	26·04	11·58	5·65	27·07	3·96	7·81	24·83	12·8	6·24	17·29
					Starch.										Starch. 9·29
Cocoa-beans, raw, not shelled	7·93	14·19	1·49	45·57	22·92		4·78	4·61	15·41	1·62	49·48	...	5·19	5·01	22·19
Cocoa, shelled and roasted	5·58	14·13	1·55	50·09	8·77	13·91	3·93	3·59	14·96	1·64	53·05	...	4·16	3·80	...
Cocoa, kneaded	4·16	13·97	1·56	53·03	21·81		3·40	3·63	14·57	1·63	54·27	...	3·55	3·79	...
Cocoa-powder (German)	6·35	21·50	1·82	27·34	15·17	19·01	5·44	5·19	22·96	1·94	29·60	...	5·81	6·08	16·20
Cocoa-powder (Dutch)	4·54	19·66	1·74	13·61	12·61	17·25	5·85	8·48	20·6	1·82	33·13	...	6·13	8·89	13·22
					Sugar.										Sugar.
Chocolate	1·89	6·18	0·67	21·02	54·40	13·27	1·35	1·89	6·3	0·68	21·52	...	1·38	1·93	55·43

TABLE X. (*continued*).—C. Alcoholic Articles of Enjoyment.

In Natural State.

Beer.	Specific Gravity.	Water.	CO_2.	Alcohol.	Extract.	Nitrogenous Substance.	Sugar.	Dextrine.	Acid = Lactic Acid.	Mineral Matter.	Phosphoric Acid.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Draught beer	1·0144	91·11	0·197	3·36	5·34	0·74	0·95	3·11	0·156	0·204	0·055
Lager beer	1·0162	90·08	0·196	3·93	5·79	0·71	0·88	3·73	0·151	0·228	0·077
Export beer	1·0176	89·01	0·209	4·40	6·38	0·74	1·20	2·47	0·161	0·247	0·074
Bock	1·0213	87·87	0·234	4·68	7·21	0·73	1·81	3·97	0·165	0·263	0·089
White beer	1·0137	91·63	0·297	2·73	5·34	0·58	1·62	2·42	0·392	0·149	0·034
Old beer, top ferment.	1·0102	92·92	0·162	2·79	4·13	0·41	0·85	1·75	0·433	0·174	0·049
Ale	1·0141	89·42	0·201	4·73	5·65	0·61	1·07	1·81	0·278	0·310	0·086
Porter	1·0191	88·49	0·215	4·70	6·59	0·65	2·62	3·08	0·281	0·363	0·093

In Original State.

Wines.	Specific Gravity.	Alcohol.	Extract.	Acid (as Tartaric Acid).	Sugar.	Nitrogen.	Tannin and Pigment.	Mineral Matter.	Phosphoric Acid.	Sulphuric Acid.	Potassa.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Must	1·0780	...	18·78	0·92	16·05	0·051	...	0·266	0·039	0·011	0·148
					Glycerine.						
Moselle wine	0·9964	7·99	2·24	0·79	0·72	0·031	...	0·175	0·036	0·026	0·068
Hessian Rhenish (white)	...	9·91	2·52	0·56	1·02	...	...	0·250	0·046	0·048	...
„ „ (red)	0·9961	7·70	3·01	0·58	...	...	0·148	0·218	...	...	...
Palatinate (white)	...	8·11	2·43	0·67	1·12	...	...	0·210	0·034	0·034	0·099
„ (red)	...	9·39	2·94	0·49	1·29	...	...	0·240	0·038	0·029	0·095
Franconian	0·9962	7·75	2·31	0·74	0·90	...	...	0·217	0·034	0·040	0·117
Sweet Wines.											
							Sugar.				
Tokay (dry)	0·9943	12·05	3·26	0·68	1·04	0·041	0·63	0·24	0·035	0·030	0·108
„ (Ausbruch)	1·0870	9·44	23·63	0·57	0·62	0·060	19·44	0·32	0·054	0·034	0·116
Port	1·0081	16·69	8·05	0·40	0·43	0·027	5·82	0·23	0·031	0·023	0·102
Madeira	1·0003	15·40	5·52	0·43	0·74	0·020	3·23	0·35	0·060	0·075	0·149
Malaga	1·0694	11·93	21·73	0·55	0·46	0·041	17·11	0·41	0·049	0·043	0·187

TABLE X. (*continued*).

Spirits and Liqueurs.	Water.	Alcohol.	Extract.	Acid = Acetic Acid.	Sugar.	Mineral Matter.
	Grm. in 100 *cc.*	*Grm.* in 100 *cc.*	*Grm.* in 100 *cc.*	*Grm.* in 100 *cc.*	*Grm.* in 100 *cc.*	*Grm.* in 100 *cc.*
Common brandy	64·90	35·1	...	...	...	...
Cherry brandy	56·0	43·9	0·055	...	...	0·018
Cognac	55·6	43·9	0·385	0·067	...	0·024
Rum	36·5	61·4	1·975	...	...	0·060
Arack	47·4	52·5	0·082	...	...	0·024
Kümmel[1]	39·98	28	32·02	...	31·18	0·058
Peppermint	23·15	28·6	48·25	...	47·23	0·068
Chartreuse	27·69	36·2	36·11	...	34·35	...

[1] A liquor containing oil of carraway seed.—*Editor.*

D. Vinegars.

	Alcohol.	Extract.	Volatile Acid = Acetic Acid.	Fixed Acid = Tartaric Acid.	Tartar.	Glycerine.	Mineral Matter.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Common vinegar	trace	0·43	4·02	...	...	...	0·113
Spirit vinegar	0·63	0·30	11·55	trace	...	0·010	0·031
Wine vinegar	1·05	1·066	5·77	0·149	0·124	0·211	0·184

E. Sugars, Syrups, Honey.

	In Natural State.						Dried.				
	Water.	Nitrogenous Matter.	Saccharose.	Grape Sugar.	Non-Nitrogenous Extract.	Ash.	Nitrogenous Matter.	Saccharose.	Grape Sugar.	Non-Nitrogenous Extractive.	Ash.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Cane-sugar[1]	2·16	0·35	93·33	1·78	1·21	0·7	0·35	95·38	1·82	...	0·78
Beet-sugar, medium	0·23	...	98·70	...	0·23	0·84	...	98·90	...	...	0·83
Starch-sugar	16·99	...	...	64·33	18·02	0·6	...	77·52	22·05	...	0·43
Starch-sugar syrup	19·58	...	...	41·09	38·37	0·36	...	50·82	48·82	...	0·36

[1] The "cane-sugar" here given must be crude.—*Editor.*

TABLE XI.

Table of Corrections for New (Unskimmed) Milk.

TEMPERATURE OF MILK.

Degrees of Lactodensimeter.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
14	12·9	12·9	12·9	13	13	13·1	13·1	13·1	13·2	13·3	13·4	13·5	13·6	13·7	13·8	14	14·1	14·2	14·4	14·6	14·8	15	15·2	15·4	15·6	15·8	16	16·2	16·4	16·6	16·8
15	13·9	13·9	13·9	14	14	14·1	14·1	14·1	14·2	14·3	14·4	14·5	14·6	14·7	14·8	15	15·1	15·2	15·4	15·6	15·8	16	16·2	16·4	16·7	16·8	17	17·2	17·4	17·6	17·8
16	14·9	14·9	14·9	15	15	15·1	15·1	15·1	15·2	15·3	15·4	15·5	15·6	15·7	15·8	16	16·1	16·3	16·5	16·7	16·9	17·1	17·3	17·5	17·7	17·9	18·1	18·3	18·5	18·7	18·9
17	15·9	15·9	15·9	16	16	16·1	16·1	16·1	16·2	16·3	16·4	16·5	16·6	16·7	16·8	17	17·1	17·3	17·5	17·7	17·9	18·1	18·3	18·5	18·7	18·9	19·1	19·3	19·5	19·7	20
18	16·9	16·9	16·9	17	17	17·1	17·1	17·1	17·2	17·3	17·4	17·5	17·6	17·7	17·8	18	18·1	18·3	18·5	18·7	18·9	19·1	19·3	19·5	19·7	19·9	20·1	20·3	20·5	20·7	21
19	17·8	17·8	17·8	17·9	17·9	18	18·1	18·1	18·2	18·3	18·4	18·5	18·6	18·7	18·8	19	19·1	19·3	19·5	19·7	19·9	20·1	20·3	20·5	20·7	20·9	21·1	21·3	21·5	21·7	22
20	18·7	18·7	18·7	18·8	18·8	18·9	19	19	19·1	19·2	19·3	19·4	19·5	19·6	19·8	20	20·1	20·3	20·5	20·7	20·9	21·1	21·3	21·5	21·7	21·9	22·1	22·3	22·5	22·7	23
21	19·6	19·6	19·7	19·7	19·7	19·8	19·9	20	20·1	20·2	20·3	20·4	20·5	20·6	20·8	21	21·2	21·4	21·6	21·8	22	22·2	22·4	22·6	22·8	23	23·2	23·4	23·6	23·8	24·1
22	20·6	20·6	20·7	20·7	20·7	20·8	20·9	21	21·1	21·2	21·3	21·4	21·5	21·6	21·8	22	22·3	22·4	22·6	22·8	23	23·2	23·4	23·6	23·8	24·1	24·3	24·5	24·7	24·9	25·2
23	21·5	21·5	21·6	21·7	21·7	21·8	21·9	22	22·1	22·2	22·3	22·4	22·5	22·6	22·8	23	23·2	23·4	23·6	23·8	24	24·2	24·4	24·6	24·8	25·1	25·3	25·5	25·7	26	26·3
24	22·4	22·4	22·5	22·6	22·7	22·8	22·9	23	23·1	23·2	23·3	23·4	23·5	23·6	23·8	24	24·2	24·4	24·6	24·8	25	25·2	25·4	25·6	25·8	26·1	26·3	26·5	26·7	27	27·3
25	23·3	23·3	23·4	23·5	23·6	23·7	23·8	23·9	24	24·1	24·2	24·3	24·5	24·6	24·8	25	25·2	25·4	25·6	25·8	26	26·2	26·4	26·6	26·8	27·1	27·3	27·5	27·7	28	28·3
26	24·3	24·3	24·4	24·5	24·6	24·7	24·8	24·9	25	25·1	25·2	25·3	25·5	25·6	25·8	26	26·2	26·4	26·6	26·9	27·1	27·3	27·5	27·7	27·9	28·2	28·4	28·6	28·9	29·2	29·5
27	25·2	25·3	25·4	25·5	25·6	25·7	25·8	25·9	26	26·1	26·2	26·3	26·5	26·6	26·8	27	27·2	27·4	27·6	27·9	28·2	28·4	28·6	28·8	29	29·3	29·5	29·7	30	30·3	30·6
28	26·1	26·2	26·3	26·4	26·5	26·6	26·7	26·8	26·9	27	27·1	27·2	27·4	27·6	27·8	28	28·2	28·4	28·6	28·9	29·2	29·4	29·6	29·9	30·1	30·4	30·6	30·8	31·1	31·4	31·7
29	27	27·1	27·2	27·3	27·4	27·5	27·6	27·7	27·8	27·9	28·1	28·2	28·4	28·6	28·8	29	29·2	29·4	29·6	29·9	30·2	30·4	30·6	30·9	31·2	31·5	31·7	31·9	32·2	32·5	32·8
30	27·9	28	28·1	28·2	28·3	28·4	28·5	28·6	28·7	28·8	29	29·2	29·4	29·6	29·8	30	30·2	30·4	30·6	30·9	31·2	31·4	31·6	31·9	32·2	32·5	32·7	33	33·3	32·6	33·9
31	28·8	28·9	29	29·1	29·2	29·3	29·5	29·6	29·7	29·8	30	30·2	30·4	30·6	30·8	31	31·2	31·4	31·7	32	32·3	32·5	32·7	33	33·3	33·6	33·8	34·1	34·4	34·7	35·1
32	29·7	29·8	29·9	30	30·1	30·3	30·4	30·5	30·6	30·8	31	31·2	31·4	31·6	31·8	32	32·2	32·4	32·7	33	33·3	33·6	33·8	34·1	34·4	34·7	34·9	35·2	35·5	35·8	36·2
33	30·6	30·7	30·8	30·9	31	31·2	31·3	31·4	31·6	31·8	32	32·2	32·4	32·6	32·8	33	33·2	33·4	33·7	34	34·3	34·6	34·9	35·2	35·5	35·8	36	36·3	36·6	36·9	37·3
34	31·5	31·6	31·7	31·8	31·9	32·1	32·2	32·3	32·5	32·7	32·9	33·1	33·3	33·5	33·8	34	34·2	34·4	34·7	35	35·3	35·6	35·9	36·2	36·5	36·8	37·1	37·4	37·7	38	38·4
35	32·4	32·5	32·6	32·7	32·8	33	33·1	33·2	33·4	33·6	33·8	34	34·2	34·4	34·7	35	35·2	35·4	35·7	36	36·3	36·6	36·9	37·2	37·5	37·8	38·1	38·4	38·7	39·1	39·5

TABLE XI*a*.

Table of Correction for Skimmed Milk.

TEMPERATURE OF MILK.

Degrees of Lactodensimeter.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
18	17·2	17·2	17·2	17·2	17·2	17·3	17·3	17·3	17·3	17·4	17·5	17·6	17·7	17·8	17·9	18	18·1	18·2	18·4	18·6	18·8	18·9	19·1	19·3	19·5	19·7	19·9	20·1	20·3	20·5	20·7
19	18·2	18·2	18·2	18·2	18·2	18·3	18·3	18·3	18·3	18·4	18·5	18·6	18·7	18·8	18·9	19	19·1	19·2	19·4	19·6	19·8	19·9	20·1	20·3	20·5	20·7	20·9	21·1	21·3	21·5	21·7
20	19·2	19·2	19·2	19·2	19·2	19·3	19·3	19·3	19·3	19·4	19·5	19·6	19·7	19·8	19·9	20	20·1	20·2	20·4	20·6	20·8	20·9	21·1	21·3	21·5	21·7	21·9	22·1	22·3	22·5	22·7
21	20·2	20·2	20·2	20·2	20·2	20·2	20·3	20·3	20·3	20·4	20·5	20·6	20·7	20·8	20·9	21	21·1	21·2	21·4	21·6	21·8	21·9	22·1	22·3	22·5	22·7	22·9	23·1	23·4	23·5	23·7
22	21·1	21·2	21·1	21·1	21·2	21·3	21·3	21·3	21·3	21·4	21·5	21·6	21·7	21·8	21·9	22	22·1	22·2	22·4	22·6	22·8	22·9	23·1	23·3	23·5	23·7	23·9	24·1	24·3	24·5	24·7
23	22	22	22	22	22·1	22·2	22·3	22·3	22·3	22·4	22·5	22·6	22·7	22·8	22·9	23	23·1	23·2	23·4	23·6	23·8	23·9	24·1	24·3	24·5	24·7	24·9	25·1	25·3	25·5	25·7
24	22·9	22·9	22·9	22·9	23	23·1	23·2	23·2	23·2	23·3	23·4	23·5	23·6	23·7	23·9	24	24·1	24·2	24·4	24·6	24·8	24·9	25·1	25·3	25·5	25·7	25·9	26·1	26·3	26·5	26·7
25	23·8	23·8	23·8	23·8	23·9	24	24·1	24·1	24·1	24·2	24·3	24·4	24·5	24·6	24·8	25	25·1	25·2	25·4	25·6	25·8	25·9	26·1	26·3	26·5	26·7	26·9	27	27·2	27·4	27·6
26	24·8	24·8	24·8	24·8	24·9	25	25·1	25·1	25·1	25·2	25·3	25·4	25·5	25·6	25·8	26	26·1	26·3	26·5	26·7	26·9	27	27·2	27·4	27·6	27·8	28	28·2	28·4	28·6	28·8
27	25·8	25·8	25·8	25·8	25·9	26	26·1	26·1	26·1	26·2	26·3	26·4	26·5	26·6	26·6	27	27·1	27·3	27·5	27·7	27·9	28·1	28·3	28·5	28·7	28·9	29·1	29·3	29·5	29·7	29·9
28	26·8	26·8	26·8	26·8	26·9	27	27·1	27·1	27·1	27·2	27·3	27·4	27·5	27·6	27·8	28	28·1	28·3	28·5	28·7	28·9	29·1	29·3	29·5	29·7	29·9	30·1	30·3	30·5	30·7	31
29	27·8	27·8	27·8	27·8	27·9	28	28·1	28·1	28·1	28·2	28·3	28·4	28·5	28·6	28·8	29	29·1	29·3	29·5	29·7	29·9	30·1	30·3	30·5	30·7	30·9	31·1	31·3	31·5	31·7	32
30	28·7	28·7	28·7	28·7	28·8	28·9	29	29	29·1	29·2	29·3	29·4	29·5	29·6	29·8	30	30·1	30·3	30·5	30·7	30·9	31·1	31·3	31·5	31·7	31·9	32·1	32·3	32·5	32·7	33
31	29·7	29·7	29·7	29·7	29·8	29·9	30	30	30·1	30·2	30·3	30·4	30·5	30·6	30·8	31	31·2	31·4	31·6	31·8	32	32·2	32·4	32·6	32·8	33	33·2	33·4	33·6	33·9	34·1
32	30·7	30·7	30·7	30·7	30·8	30·9	31	31	31·1	31·2	31·3	31·4	31·5	31·6	31·8	32	32·2	32·4	32·6	32·8	33	33·2	33·4	33·6	33·9	34·1	34·3	34·5	34·7	35	35·2
33	31·7	31·7	31·7	31·7	31·8	31·9	32	32	32·1	32·2	32·3	32·4	32·5	32·6	32·8	33	33·2	33·4	33·6	33·8	34	34·2	34·4	34·6	34·9	35·2	35·4	35·6	35·8	36·1	36·3
34	32·6	32·6	32·6	32·7	32·8	32·9	32·9	33	33·1	33·2	33·3	33·4	33·5	33·6	33·8	34	34·2	34·4	34·6	34·8	35	35·2	35·4	35·6	35·9	36·2	36·4	36·7	36·9	37·2	37·4
35	33·5	33·5	33·5	33·6	33·7	33·9	33·8	33·9	34	34·1	34·2	34·3	34·4	34·6	34·8	35	35·2	35·4	35·6	35·8	36	36·2	36·4	36·6	36·9	37·2	37·4	37·7	38	38·3	38·5
36	34·4	34·4	34·5	34·6	34·7	34·8	34·9	34·9	35	35·1	35·2	35·3	35·4	35·6	35·8	36	36·2	36·4	36·6	36·9	37·1	37·3	37·5	37·7	38	38·3	38·5	38·8	39·1	39·4	39·7
37	35·3	35·4	35·5	35·6	35·7	35·8	35·8	36	36·1	36·2	36·3	36·4	36·6	36·8	37	37·2	37·4	37·6	37·9	38·2	38·4	38·6	38·8	39·1	39·4	39·6	39·9	40·2	40·5	40·8
38	36·2	36·3	36·4	36·5	36·6	36·7	36·8	36·9	37	37·1	37·2	37·3	37·4	37·6	37·8	38	38·2	38·4	38·6	38·9	39·2	39·4	39·7	39·9	40·2	40·5	40·7	41	41·3	41·6	41·9
39	37·1	37·2	37·3	37·4	37·5	37·6	37·7	37·8	37·9	38	38·2	38·3	38·4	38·6	38·8	39	39·2	39·4	39·6	39·9	40·2	40·4	40·7	41	41·3	41·6	41·8	42·1	42·4	42·7	43
40	38	38·1	38·2	38·3	38·4	38·5	38·6	38·7	38·8	38·9	39·1	39·2	39·4	39·6	39·6	40	40·2	40·4	40·6	40·9	41·2	41·4	41·7	42	42·3	42·6	42·9	43·2	43·5	43·8	44·1

TABLE XII.

Showing the Fat of Milk in Weight per Cent. according to the Specific Gravity of the Ethereal Solution of the Fat at 17·5°.[1]

Spec. Grav	Fat per Cent.	Spec. Grav.	Fat per Cent.	Spec. Grav.	Fat per Cent.	Spec. Grav.	Fat per Cent.	Spec. Grav.	Fat per Cent.	Spec. Grav.	Fat per Cent.
43	2·07	**47**	2·52	**51**	3·00	**55**	3·49	**59**	4·03	**63**	4·63
43·1	2·08	47·1	2·54	51·1	3·01	55·1	3·51	59·1	4·04	63·1	4·64
43·2	2·09	47·2	2·55	51·2	3·03	55·2	3·52	59·2	4·06	63·2	4·66
43·3	2·10	47·3	2·56	51·3	3·04	55·3	3·53	59·3	4·07	63·3	4·67
43·4	2·11	47·4	2·57	51·4	3·05	55·4	3·55	59·4	4·09	63·4	4·69
43·5	2·12	47·5	2·58	51·5	3·06	55·5	3·56	59·5	4·11	63·5	4·70
43·6	2·13	47·6	2·60	51·6	3·08	55·6	3·57	59·6	4·12	63·6	4·71
43·7	2·14	47·7	2·61	51·7	3·09	55·7	3·59	59·7	4·14	63·7	4·73
43·8	2·16	47·8	2·62	51·8	3·10	55·8	3·60	59·8	4·15	63·8	4·75
43·9	2·17	47·9	2·63	51·9	3·11	55·9	3·61	59·9	4·16	63·9	4·77
44	2·18	**48**	2·64	**52**	3·12	**56**	3·63	**60**	4·18	**64**	4·79
44·1	2·19	48·1	2·66	52·1	3·14	56·1	3·64	60·1	4·19	64·1	4·80
44·2	2·20	48·2	2·67	52·2	3·15	56·2	3·65	60·2	4·20	64·2	4·82
44·3	2·22	48·3	2·68	52·3	3·16	56·3	3·67	60·3	4·21	64·3	4·84
44·4	2·23	48·4	2·70	52·4	3·17	56·4	3·68	60·4	4·23	64·4	4·85
44·5	2·24	48·5	2·71	52·5	3·18	56·5	3·69	60·5	4·24	64·5	4·87
44·6	2·25	48·6	2·72	52·6	3·20	56·6	3·71	60·6	4·26	64·6	4·88
44·7	2·26	48·7	2·73	52·7	3·21	56·7	3·72	60·7	4·27	64·7	4·90
44·8	2·27	48·8	2·74	52·8	3·22	56·8	3·73	60·8	4·29	64·8	4·92
44·9	2·28	48·9	2·75	52·9	3·23	56·9	3·74	60·9	4·30	64·9	4·93
45	2·30	**49**	2·76	**53**	3·25	**57**	3·75	**61**	4·32	**65**	4·95
45·1	2·31	49·1	2·77	53·1	3·26	57·1	3·76	61·1	4·33	65·1	4·97
45·2	2·32	49·2	2·78	53·2	3·27	57·2	3·78	61·2	4·35	65·2	4·98
45·3	2·33	49·3	2·79	53·3	3·28	57·3	3·80	61·3	4·36	65·3	5·00
45·4	2·34	49·4	2·80	53·4	3·29	57·4	3·81	61·4	4·37	65·4	5·02
45·5	2·35	49·5	2·81	53·5	3·30	57·5	3·82	61·5	4·39	65·5	5·04
45·6	2·36	49·6	2·83	53·6	3·31	57·6	3·84	61·6	4·40	65·6	5·05
45·7	2·37	49·7	2·84	53·7	3·33	57·7	3·85	61·7	4·42	65·7	5·07
45·8	2·38	49·8	2·86	53·8	3·34	57·8	3·87	61·8	4·44	65·8	5·09
45·9	2·39	49·9	2·87	53·9	3·35	57·9	3·88	61·9	4·46	65·9	5·11
46	2·40	**50**	2·88	**54**	3·37	**58**	3·90	**62**	4·47	**66**	5·12
46·1	2·42	50·1	2·90	54·1	3·38	58·1	3·91	62·1	4·48		
46·2	2·43	50·2	2·91	54·2	3·39	58·2	3·92	62·2	4·50		
46·3	2·44	50·3	2·92	54·3	3·40	58·3	3·93	62·3	4·52		
46·4	2·45	50·4	2·93	54·4	3·41	58·4	3·95	62·4	4·53		
46·5	2·46	50·5	2·94	54·5	3·43	58·5	3·96	62·5	4·55		
46·6	2·47	50·6	2·96	54·6	3·45	58·6	3·98	62·6	4·56		
46·7	2·49	50·7	2·97	54·7	3·46	58·7	3·99	62·7	4·58		
46·8	2·50	50·8	2·98	54·8	3·47	58·8	4·01	62·8	4·59		
46·9	2·51	50·9	2·99	54·9	3·48	58·9	4·02	62·9	4·61		

[1] Instead of the complete figures for the specific gravity, only the 2nd, 3rd, and 4th decimal places are here given, corresponding to the scale on the hydrometer; thus, *e.g.*, the number 43·0 represents the specific gravity 0·7430.

TABLE XIIa.

Showing Proportion by Weight of Fat in Skimmed Milk, according to the Specific Gravity of the Solution in Ether at 17·5°, according to Soxhlet.

Specific Gravity.	Fat per Cent.	Specific Gravity.	Fat per Cent.	Specific Gravity.	Fat per Cent.	Specific Gravity.	Fat per Cent.	Specific Gravity.	Fat per Cent.
21·1	0·00	25·5	0·41	29·9	0·82	34·3	1·22	38·7	1·64
21·2	0·01	25·6	0·42	30	0·83	34·4	1·23	38·8	1·65
21·3	0·02	25·7	0·43	30·1	0·84	34·5	1·24	38·9	1·66
21·4	0·03	25·8	0·44	30·2	0·85	34·6	1·24	39	1·67
21·5	0·04	25·9	0·45	30·3	0·86	34·7	1·25	39·1	1·68
21·6	0·05	26	0·46	30·4	0·87	34·8	1·26	39·2	1·69
21·7	0·06	26·1	0·47	30·5	0·88	34·9	1·27	39·3	1·70
21·8	0·07	26·2	0·48	30·6	0·88	35	1·28	39·4	1·71
21·9	0·08	26·3	0·49	30·7	0·89	35·1	1·29	39·5	1·72
22	0·09	26·4	0·50	30·8	0·90	35·2	1·30	39·6	1·73
22·1	0·10	26·5	0·50	30·9	0·91	35·3	1·31	39·7	1·74
22·2	0·11	26·6	0·51	31	0·92	35·4	1·32	39·8	1·75
22·3	0·12	26·7	0·52	31·1	0·93	35·5	1·33	39·9	1·76
22·4	0·13	26·8	0·53	31·2	0·94	35·6	1·33	40	1·77
22·5	0·14	26·9	0·54	31·3	0·95	35·7	1·34	40·1	1·78
22·6	0·15	27	0·55	31·4	0·95	35·8	1·35	40·2	1·79
22·7	0·16	27·1	0·56	31·5	0·96	35·9	1·36	40 3	1·80
22·8	0·17	27·2	0·57	31·6	0·97	36	1·37	40·4	1·81
22·9	0·18	27·3	0·58	31·7	0·98	36·1	1·38	40·5	1·82
23	0·19	27·4	0·59	31·8	0·99	36·2	1·39	40·6	1·83
23·1	0·20	27·5	0·60	31·9	1·00	36·3	1·40	40·7	1·84
23·2	0·21	27·6	0·60	32	1·01	36·4	1·41	40·8	1·85
23·3	0·22	27·7	0·61	32·1	1·02	36·5	1·42	40·9	1·86
23·4	0·23	27·8	0·62	32·2	1·03	36·6	1·43	41	1·87
23·5	0·24	27·9	0·63	32·3	1·04	36·7	1·44	41·1	1·88
23·6	0·25	28	0·64	32·4	1·05	36·8	1·45	41·2	1·89
23·7	0·25	28·1	0·65	32·5	1·05	36·9	1·46	41·3	1·90
23·8	0·26	28·2	0·66	32·6	1·06	37	1·47	41·4	1·91
23·9	0·27	28·3	0·67	32·7	1·07	37·1	1·48	41·5	1·92
24	0·28	28·4	0·68	32·8	1·08	37·2	1·49	41·6	1·93
24·1	0·29	28·5	0·69	32·9	1·09	37·3	1·50	41·7	1·94
24·2	0·30	28·6	0·70	33	1·10	37·4	1·51	41·8	1·95
24·3	0·30	28·7	0·71	33·1	1·11	37·5	1·52	41·9	1·96
24·4	0·31	28·8	0·72	33·2	1·12	37·6	1·53	42	1·97
24·5	0·32	28·9	0·73	33·3	1·13	37·7	1·54	42·1	1·98
24·6	0·33	29	0·74	33·4	1·14	37·8	1·55	42·2	1·99
24·7	0·34	29·1	0·75	33·5	1·15	37·9	1·56	42·3	2·00
24·8	0·35	29·2	0·76	33·6	1·15	38	1·57	42·4	2·01
24·9	0·36	29·3	0·77	33·7	1·16	38·1	1·58	42·5	2·02
25	0·37	29·4	0·78	33·8	1·17	38·2	1·59	42·6	2·03
25·1	0·38	29·5	0·79	33·9	1·18	38·3	1·60	42·7	2·04
25·2	0·39	29·6	0·80	34	1·19	38·4	1·61	42·8	2 05
25·3	0·40	29·7	0·80	34·1	1·20	38·5	1·62	42·9	2·06
25·4	0·40	29·8	0·81	34·2	1·21	38·6	1·63	43	2·07

TABLE XIII.[1]

Extract Table for Beer, according to Schultze-Ostermann.

100 *grm.* beer contains *grm.* extract.

Sp. Gr. of the De-Alcoholised Beer.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
1·011	2·87	2·90	2·92	2·95	2·97	3·00	3·03	3·06	3·08	3·11
2	3·13	3·16	3·18	3·21	3·24	3·26	3·29	3·31	3·34	3·37
3	3·39	3·42	3·44	3·47	3·49	3·52	3·55	3·57	3·60	3·62
4	3·65	3·67	3·70	3·73	3·75	3·78	3·80	3·83	3·86	3·88
5	3·91	3·93	3·96	3·98	4·01	4·04	4·06	4·09	4·11	4·14
6	4·16	4·19	4·21	4·24	4·27	4·29	4·32	4·34	4·37	4·39
7	4·42	4·44	4·47	4·50	4·52	4·55	4·57	4·60	4·62	4·65
8	4·67	4·70	4·73	4·75	4·78	4·80	4·83	4·85	4·88	4·90
9	4·93	4·96	4·98	5·01	5·03	5·06	5·08	5·11	5·13	5·16
1·020	5·19	5·21	5·24	5·26	5·29	5·31	5·34	5·36	5·39	5·41
1	5·44	5·47	5·49	5·53	5·54	5·57	5·59	5·62	5·64	5·67
2	5·69	5·72	5·74	5·77	5·80	5·82	5·85	5·87	5·90	5·92
3	5·95	5·97	6·00	6·02	6·05	6·08	6·10	6·13	6·15	6·18
4	6·20	6·23	6·25	6·28	6·30	6·33	6·35	6·38	6·40	6·43
5	6·45	6·48	6·50	6·53	6·55	6·58	6·61	6·63	6·66	6·68
6	6·71	6·73	6·76	6·78	6·81	6·83	6·86	6·88	6·91	6·93
7	6·96	6·98	7·01	7·03	7·06	7·08	7·11	7·13	7·16	7·18
8	7·21	7·24	7·26	7·29	7·31	7·34	7·36	7·39	7·41	7·44
9	7·46	7·49	7·51	7·54	7·56	7·59	7·61	7·64	7·66	7·69
1·030	7·71	7·74	7·76	7·79	7·81	7·84	7·86	7·89	7·91	7·94
1	7·99	8·01	8·04	8·06	8·09	8·11	8·14	8·16	8·19	8·21

As supplement in order to use the table for sweet wines :—

1·03	7·94	8·18	8·42	8·86	8·96	9·25	9·54	9·80	10·06	10·31
1·04	10·57	10·83	10·12	10·37	11·64	11·91	12·19	12·45	12·72	12·99
1·05	13·26	13·53	13·80	14·07	14·34	14·62	14·90	15·18	15·47	15·77
1·06	16·05	16·30	16·55	16·80	17·06	17·31	17·59	17·86	18·15	18·42
1·07	18·70	18·96	19·22	19·47	19·74	19·98	20·24	20·48	20·73	20·98

[1] In Tables XIII., XIV., and XV. the horizontal columns 0, 1, 2, 3 show the fourth decimal of the specific gravity; in the small supplemental table for sweet wines, the third place.

TABLE XIV.

Alcohol Table for Beer at 15°, *according to Holzner-Baumhauer.*

100 *grm.* beer contain *grm.* alcohol.

Specific Gravity of Distillate.	9.	8.	7.	6.	5.	4.	3.	2.	1.	0.
0·997	1·12	1·17	1·22	1·28	1·33	1·38	1·44	1·49	1·54	1·60
6	1·65	1·71	1·77	1·82	1·88	1·94	2·00	2·05	2·11	2·17
5	2·22	2·28	2·34	2·40	2·45	2·51	2·57	2·72	2·68	2·74
4	2·80	2·85	2·91	2·97	3·03	3·08	3·14	3·20	3·26	3·31
3	3·37	3·43	3·49	3·54	3·60	3·66	3·72	3·77	3·83	3·89
2	3·95	4·00	4·07	4·13	4·19	4·25	4·31	4·37	4·44	4·50
1	4·56	4·62	4·69	4·75	4·81	4·87	4·93	5·00	5·06	5·12
0	5·18	5·25	5·31	5·37	5·43	5·49	5·56	5·62	5·69	5·75
0·989	5·82	5·89	5·96	6·02	6·09	6·16	6·23	6·29	6·36	6·43
8	6·50	6·57	6·63	6·70	6·77	6·84	6·90	6·97	7·04	7·11

TABLE XV.

Alcohol Table for Wine at 15·5°, *according to Hehner.*

100 *cc.* wine contain *grm.* alcohol.

Specific Gravity of Distillate.	9.	8.	7.	6.	5.	4.	3.	2.	1.	0.
0·994	2·89	2·94	3·09	3·06	3·12	3·18	3·24	3·29	3·35	3·41
3	3·47	3·53	3·59	3·65	3·71	3·76	3·82	3·88	3·94	4·00
2	4·06	4·12	4·19	4·25	4·31	4·37	4·44	4·50	4·56	4·62
1	4·69	4·75	4·81	4·87	4·94	5·00	5·06	5·12	5·19	5·25
0	5·31	5·37	5·44	5·50	5·56	5·62	5·69	5·75	5·81	5·87
0·989	5·94	6·00	6·07	6·14	6·21	6·28	6·36	6·43	6·50	6·57
8	6·64	6·71	6·78	6·86	6·93	7·00	7·07	7·13	7·20	7·27
7	7·33	7·40	7·47	7·53	7·60	7·67	7·73	7·80	7·87	7·93
6	8·00	8·07	8·14	8·21	8·29	8·36	8·43	8·50	8·57	8·64
5	8·71	8·79	8·86	8·93	9·00	9·07	9·14	9·21	9·29	9·36
4	9·43	9·50	9·57	9·64	9·71	9·79	9·86	9·93	10·00	10·08
3	10·15	10·23	10·31	10·38	10·46	10·54	10·62	10·69	10·77	10·85
2	10·92	11·00	11·08	11·15	11·23	11·31	11·38	11·46	11·54	11·62
1	11·69	11·77	11·85	11·92	12·00	12·08	12·15	12·23	12·31	12·38
0	12·46	12·54	12·62	12·69	12·77	12·85	12·92	13·00	13·08	13·15
0·979	13·23	13·31	13·38	13·46	13·54	13·62	13·69	13·77	13·85	13·92
8	14·00	14·09	14·18	14·27	14·36	14·45	14·55	14·64	14·73	14·82
7	14·91	15·00	15·08	15·17	15·25	15·33	15·42	15·50	15·58	15·67
6	15·75	15·83	15·92	16·00	16·08	16·15	16·23	16·31	16·38	16·46
5	16·54	16·62	16·69	16·77	16·85	16·92	17·00	17·08	17·17	17·25
4	17·33	17·42	17·50	17·58	17·67	17·75	17·83	17·92	18·00	18·08
3	18·15	18·23	18·31	18·38	18·46	18·54	18·62	18·69	18·77	18·85
2	18·92	19·00	18·08	19·17	19·25	19·33	19·42	19·50	19·58	19·67
1	19·75	19·83	19·92	20·00	...	...	...	...	...	...

TABLE XVI.

Determination of Alcohol in Percentage by Weight and Volume.

Specific Gravity.	Weight.	Volume.	Specific Gravity.	Weight.	Volume.	Specific Gravity.	Weight.	Volume.
0·971	20·50	25·07	0·940	39·80	47·13	0·909	54·00	61·84
0·970	21·31	26·04	0·939	40·30	47·67	0·908	54·48	62·31
0·969	22·08	26·95	0·938	40·80	48·21	0·907	54·95	62·79
0·968	22·85	27·86	0·937	41·30	48·75	0·906	55·21	63·24
0·967	23·62	28·77	0·936	41·80	49·29	0·905	55·86	63·69
0·966	24·38	29·67	0·935	42·29	49·81	0·904	56·32	64·14
0·965	25·14	30·57	0·934	42·76	50·31	0·903	56·77	64·58
0·964	25·86	31·40	0·933	43·24	50·32	0·902	57·21	65·01
0·963	26·53	32·19	0·932	43·71	51·32	0·901	57·63	65·41
0·962	27·21	32·98	0·931	44·18	51·32	0·900	58·05	65·81
0·961	27·93	33·81	0·930	44·64	52·29	0·899	58·50	66·25
0·960	28·56	34·54	0·929	45·09	52·77	0·898	58·95	66·69
0·959	29·20	35·28	0·928	45·55	53·24	0·897	59·39	67·11
0·958	29·37	36·04	0·927	46·00	53·72	0·896	59·83	67·53
0·957	30·44	36·70	0·926	46·46	54·19	0·895	60·26	67·93
0·956	31·00	37·34	0·925	46·91	54·66	0·894	60·67	68·33
0·955	31·62	38·04	0·924	47·36	55·13	0·893	61·02	68·72
0·954	32·25	38·75	0·923	47·82	55·60	0 892	61·50	69·11
0·953	32·87	39·47	0·922	48·27	56·07	0·891	61·92	69·50
0·952	33·47	40·14	0·921	48·73	56·54	0 890	62·36	69·92
0·951	34·05	40·79	0·920	49·16	56·98	0·889	62·82	70·35
0·950	34·52	41·32	0·919	49·64	57·45	0·888	63·26	70·77
0·949	35·00	41·34	0·918	50·09	57·92	0·887	63·70	71·17
0·948	35·50	42·40	0·917	50·52	58·36	0·886	64·13	71·58
0·947	36·00	42·95	0·916	50·96	58·80	0·885	64·57	71·95
0·946	36·56	43·56	0·915	51·38	59·22	0·884	65·06	72·38
0·945	37·11	44·18	0·914	51·79	59·63	0·883	65·42	72 7
0·944	37·67	44·79	0·913	52·23	60·07	0·882	65·83	73·15
0·943	38·22	45·41	0·912	52·53	60·52	0·881	66·26	73·5
0·942	38·78	46·02	0·911	53·13	60·97	0·880	66·70	73·93
0·941	39·30	46·59	0·910	53·57	61·40			

TABLE XVII.

Atomic Weights Abridged to the First Decimal Place, according to L. Meyer and Seubert.

Name.	Sign.	Atomic Weight.	Name.	Sign.	Atomic Weight.
Aluminium	Al	27·0	Manganese	Mn	54·8
Arsenic	As	74·9	Mercury	Hg	199·8
Barium	Ba	136·9	Molybdenum	Mo	95·9
Boron	B	10·9	Nickel	Ni	58·6
Bromine	Br	79·8	Nitrogen	N	14·0
Calcium	Ca	39·9	Oxygen	O	16·0
Carbon	C	12·0	Palladium	Pd	106·2
Chlorine	Cl	35·4	Phosphorus	P	31·0
Chromium	Cr	52·4	Platinum	Pt	194·3
Copper	Cu	63·2	Potassium	K	39·0
Hydrogen	H	1·0	Silver	Ag	107·7
Iodine	I	126·5	Silicon	Si	28·0
Iron	Fe	55·9	Sulphur	S	32·0
Lead	Pb	206·4	Tin	Sn	117·4
Magnesium	Mg	23·9	Uranium	U	239·8

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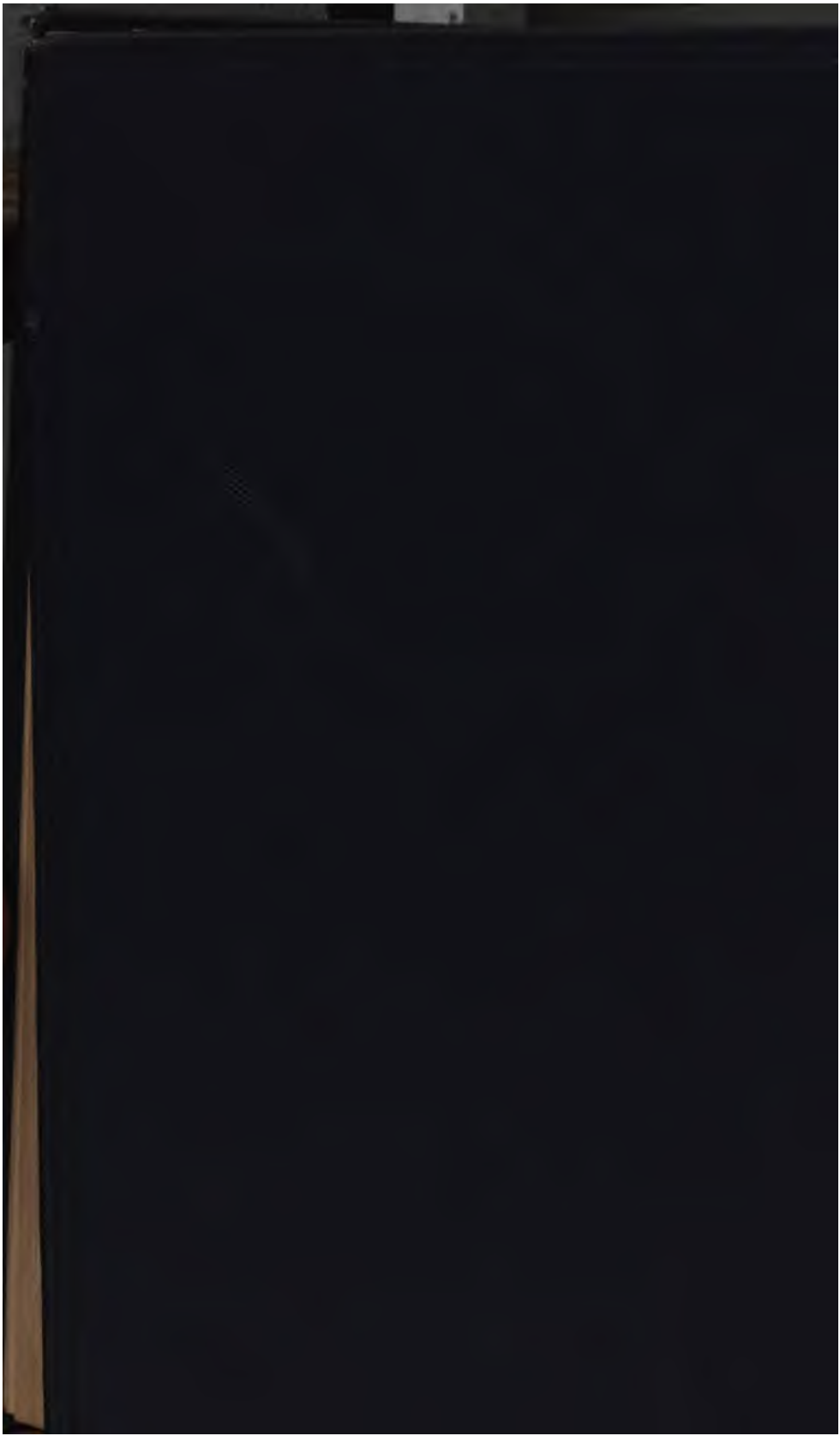
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